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DEGREE FOR WHICH THESIS WAS PRESENTED Master of Science

YEAR THIS DEGREE GRANTED 1978

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THE UNIVERSITY OF ALBERTA

Characteristics of Body and Gonad Growth of Yellow Perch, *Perca flavescens*, from Lac Ste. Anne, Alberta

by

© Ronald W. Tanasichuk

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH
IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE
OF MASTER OF SCIENCE

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EDMONTON, ALBERTA

Spring 1978

THE UNIVERSITY OF ALBERTA

FACULTY OF GRADUATE STUDIES AND RESEARCH

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled "Characteristics of Body and Gonad Growth of Yellow Perch *(Perca flavescens* L.) from

ABSTRACT

Yellow perch (*Perca flavescens*) were sampled from Lac Ste. Anne, Alberta between March 1976 and July 1977. Parameters that were measured included body weight and length, gonad weight as well as protein, lipid, water, and caloric contents of the body. Qualitative changes in body composition were examined to determine the roles played by protein, lipid, and water, in changes in body weight. Gonad protein and lipid contents were also measured. The coupling of qualitative changes in body composition with gonad growth allowed suggestions to be made as to the roles played by body constituents in gonad development.

Yellow perch from Lac Ste. Anne showed increases in length and weight from June to January. Male and female perch, during their second year of life (1+), were similiar in length and weight. Two+ females were longer and heavier than 2+ males.

Condition of 1+ perch increased during June as well as between October and January in 1+ females and between January and March in 1+ males. For 2+ females, condition increased from June to September and from January to March. Two+ males showed an increase in condition from June through August followed by a decrease until January and then an increase from January until March. For all groups, condition decreased from March through June. Changes in

condition were not correlated with changes in total somatic energy content.

Changes in total body weight were correlated with changes in total body protein content for 1+ perch and with changes in total body water content in 1+ females and 2+ perch. The major increases in body water and body protein contents occurred concurrently in 2+ males only.

Gonad growth began in August for 1+ and 2+ males, in September for 2+ females, and in October for 1+ females. Increases in gonad weight continued until at least March. Most of the protein and lipid were deposited between September and March in the 1+ male gonad. Protein and lipid were deposited most rapidly between October and January in the 2+ perch gonad. Two+ males utilized visceral fat for testes development whereas 2+ females used body protein and visceral fat in ovary development. In March, prior to spawning in May, the caloric content of the ovary was greater than that of the testes.

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I. Introduction

Temperate zone teleosts exhibit annual cycles in body growth and reproduction. Shul'man (1974) suggests that gonad maturation determines the timing and extent of body growth, in length and mass, by the demands made of the body during germinal tissue development. According to Woodhead (1960), body growth and gonad growth are alternate activities in fish. He postulates that the majority of fish show a seasonal decline in growth at the onset of maturation, the extent of which varies between species and often between sexes. Nakashima and Leggett (1975) state that, in yellow perch (*Perca flavescens*), the increased energy demands related to gonad development in sexually mature fish may be important in terminating growth in the fall.

Alternate periods of body growth and gonad development occur in European perch (*Perca fluviatilus*) (LeCren, 1951), and are suggested to occur in the yellow perch (*Perca flavescens*) (Nakashima and Leggett, 1975). In general, growth in weight and length of European and yellow perch begins in June and terminates in September or October. Gonad development in European perch males begins in August (LeCren 1951; Makarova, 1973) and in females, gonad weight begins increasing in September (LeCren, 1951; Markarova, 1973). Ovary weight of female yellow perch in Lake Michigan

begins increasing in September (Brazo et al., 1975).

Seasonal cycles in condition have been observed in the European perch (LeCren, 1951), American plaice (Hippoglossoides platessoides) (MacKinnon, 1972) and in the blue bream (Abramis ballerus) (Khashem, 1970) and seasonal cycles in condition have been correlated with gonad cycles (LeCren, 1951). LeCren (1951) suggests that, in at least European perch, a decrease in body weight is made towards the build-up of the gonad as indicated by the decline and subsequent low level of somatic body weight (total body weight minus gonad weight) throughout the winter. Northern pike from Lac Ste. Anne lost body weight rapidly from March until spawning in May (Medford, 1976). American plaice showed a large decrease in somatic body condition over winter when feeding had ceased and gonad maturation was taking place (MacKinnon, 1972).

The body mass of animals increases chiefly as a result of protein synthesis and therefore, from the physiological-biochemical standpoint, the growth of animals is primarily a result of protein synthesis (Shul'man, 1974). Protein growth of fish has been investigated little.

Markevich and Shatunovskiy (1969) and Shul'man (1974) state that lipid is the basic energy substrate in fish and that lipid is required for gonadal development. The involvement of lipid, and in some cases protein, with gonad development has been studied in a variety of fishes.

The materials for the formation of germinal products

are derived from food and from reserves built up in the organism prior to gonad recrudescence (Shul'man, 1974). Shul'man (1974) states that, in general, during the initial stages of gonad development, fat content of the body decreases due to differentiation of germinal products and then, in females continues decreasing during vitellogenesis. In pike-perch (*Stizostedion lucioperca*) females (Golvanenko et al., 1970), Baltic cod (*Gadus morhua callarias*) (Shatunovskiy, 1971), the blue bream (*Abramis ballerus*) (Khashem, 1970) and scorpionfish (*Scorpanea porcus*) (Shchepkin, 1971), lipid reserves in the liver and muscle are utilized for gonad development. Visceral fat and muscle fat reserves seem most important for gonad construction in the roach (*Rutilus rutilus*) (Vyatchanina, 1971), lake whitefish (*Coregonus clupeaformis*) (Reshetnikov, 1970), and in Arctic char (*Salvelinus alpinus*) (Matsuk and Lapin, 1972). Protein reserves as well as fat reserves are used in gonad development in Altantic herring (*Clupea harengus*) (Gakichko and Dubrovskaya, 1970) and in European perch (Makarova, 1973).

Relatively few studies of energy storage and depletion have been conducted on freshwater species of fish. Makarova (1973) examined seasonal changes in body, liver and gonad protein and fat content of *Perca fluviatilis*. He found that the greatest activity of spermotogenesis, which occurred between August and October, was made possible by liver lipid and visceral fat stores. The largest increase in ovary

weight, which took place between October and April, occurred with a minimum expenditure of lipid and utilized protein metabolism and exogenous lipid. Newsome and Leduc (1975) studied the effect of gonad development on body fat content of yellow perch from two Laurentian Lakes. They concluded that body fat was used for testes and ovary development with the fat requirement being greater for the latter. Craig (1977) examined the seasonal cycle of body composition of adult European perch. He found that more of the body reserve was required for ovary maturation.

Many studies of body growth have been conducted on yellow perch (Harkness, 1922; Langford and Martin, 1940; Hile and Jobes, 1940; Jobes, 1952; Carlander, 1950; Grimaldi and Leduc, 1973; Ney and Smith, 1975; Eschemeyer, 1936, 1937; Fortin and Magnin, 1972). It seems, in general, that body growth of yellow perch occurs between June and September although Hile and Jobes (1940) found that Saginaw Bay yellow perch continued growing until December. Female yellow and European perch show consistently faster growth rates after the second year of life (McCormack, 1965; LeCren, 1958; Carlander, 1950; Jobes, 1952; Hile and Jobes, 1940; Grimaldi and Leduc, 1973; Nakashima and Leggett, 1975).

Yellow perch, a widely distributed species in North America, is of great importance to the sport fishery and of considerable importance to the commercial fishery. Yellow perch from Lac Ste. Anne were selected for this study since

large samples of individuals could be easily obtained throughout the year. This allowed study of the growth of yellow perch through the winter. No previous study has examined the growth of perch over a one year period. The qualitative characteristics of body growth, in terms of the involvement of body constituents with increases in body weight, have not been determined on this species although a large amount of information on the quantitative characteristics of body growth exists. It has been assumed but not shown, that for fish in general, increases in body weight occur with proportional and corresponding increases in all body constituents.

In general, fish seem to use fat and/or protein reserves, located in different body regions, as substrates for gonad construction. Only Newsome and Leduc (1975) have studied the involvement of body constituents with germinal tissue construction in yellow perch (*Perca flavescens*) whereas only Makarova (1973) has examined fat and protein participation in gonad construction of the European perch (*Perca fluviatilis*).

The object of this study was, therefore, to compare the timing of and extent of body growth in 1+ and 2+ yellow perch from Lac Ste. Anne through 1 year and to examine the involvement of body constituents with body growth and gonad development in these fish.

II. Materials and Methods

A. Description of Study Area

Lac Ste. Anne, a shallow eutrophic lake, is located approximately 74 km west-northwest of Edmonton, Alberta at approximately 114° 24' W longitude and 53° 43' N latitude (Medford, 1976). The lake, which is divided into a smaller western basin and a larger eastern basin, is about 57 km² in surface area with a maximum depth of 10 m and an average depth of 4.8 m (Department of Water Resources Hydrographic Survey of Lac Ste. Anne, 1965).

B. Sampling Procedure

Yellow perch were collected between March 15, 1976 and July 3, 1977. Sampling was carried out with monofilament gillnets consisting of 15.2 m panels of 19, 25, 38 and 51 mm stretch mesh, with a 4.9 m semi-balloon otter trawl and with a 7.6 m beachseine. Appendix Table 1 gives the times and methods of sampling.

Upon capture, perch were immediately returned to the Fish Research Laboratory at Gunn, which is located on Lac Ste. Anne, where the entire sample was divided on the basis of sex (by presence of testes or ovaries) and age. Age was estimated from standard body length (body length from the tip of the snout to the hypural plate) (see Appendix A).

When the sample size permitted, twenty-four (24) individuals were selected at random from each age and sex group. If the sample size of an age-sex group was less than 24, then all individuals in that group were used. Standard length of each of these fish was measured and the left opercular bone was removed for age determination (LeCren 1947; Bardach, 1950). The gonads were removed, blotted dry, and weighed to the nearest 0.001 g. Body weight was measured to the nearest 0.001 g after removal of the gonad, emptying of stomach and intestine contents, and blotting the body dry. A maximum of twelve individuals from each subsample was selected at random for drying, for 1 to 2 days at 70° C, to a constant weight. When there were less than 12 individuals in an age-sex group, all individuals in that group were dried. Dry body weight was measured to the nearest 0.001 g and the body water content was calculated. The bodies were then ground individually with a standard household coffee mill and the resulting powder was transferred to a labelled vial. The vials were kept in a freezer at -30° C until compositional analysis of the body was carried out. The remaining individuals were placed in numbered bags containing the gonad from that individual. These fish were then stored at -30° C.

Standard length and total body weight (body weight including gonads and stomach and intestinal contents) measurements were made on all remaining individuals which were not selected for body composition analysis. Mean

condition ($K = 100W/L^3$) of each age-sex group was calculated from the mean standard length (L) and mean total body weight (W) values for each age-sex group at each sampling interval (LeCren, 1951).

Analyses of gonad composition were carried out on ovaries and testes obtained from 1+ and 2+ perch collected between September 7 and March 2. The gonads used were taken from perch whose bodies were previously selected for compositional analysis. Gonads were dried in an oven at 70° C for 2 days. The dry weight of the individual gonad was measured to the nearest 0.001 g. The gonads were ground individually with a mortar and pestle. The resulting powder was placed in a prenumbered vial and stored at about 0° C.

C. Body Composition Analysis

All body energy content determinations were carried out using a Parr Adiabatic Oxygen Bomb Calorimeter. Analysis was conducted following the procedure described in the Parr Instruction Manual. Benzoic acid (Parr Instrument Company, Moline, Ill.) was used as a standard. Duplicate ignitions of benzoic acid pellets were conducted prior to each session of calorimetry to determine variability between sessions and ignitions. Weight of the pellet of body powder ignited depended upon the amount of powder present. When possible, pellets of about 1.0 g of body powder were used although pellets as small as 0.6 g were burned.

Caloric values were calculated on a calorie per gram dry weight basis. Benzoic acid standard pellets had a mean calibration value (±1 SD) of 2482.0±124.7 cal/°C over all sessions of calorimetric analyses.

Protein content of the body was determined using the Kjeldahl nitrogen determination method (Steyermark, 1961) (Appendix B). The % nitrogen value obtained was multiplied by 6.25 to give the crude protein concentration which was calculated as a percentage of the dry body weight (Kleiber, 1975).

Body fat and visceral fat contents were determined gravimetrically following the procedure of Folch et al. (1957) (see Medford, 1976) (Appendix C). Lipids were extracted by refluxing approximately 750 mg of dried body powder in a Soxhlet apparatus for 4.5–5 hours with chloroform/ methanol (2:1). For visceral fat content determinations, lipids were extracted from dried individual viscera. The viscera were taken from individuals which were selected for but not ground for body composition analysis.

Gonad lipid content was determined spectrophotometrically using a modification of the method for total serum lipid concentration determination of Frings et al., (1972) (Appendix D). Gonads were analysed for protein content using the micro-Kjeldahl nitrogen determination as described by Steyermark (1961) (Appendix E).

D. Statistical Analysis

All determinations of body energy, body protein and body fat content were carried out during the month of capture. Five of the twelve vials from each age-sex group were selected at random for body composition analysis. The mean ($\overline{x}$) and standard deviation (s) for the analysis of body energy, body protein or body fat content of each age and sex group was calculated. These values were then inserted, as was the value of t at $p=0.05$ and $df=4$, into the equation: $\overline{x}=(s/\sqrt{n})\ t$. The 95% confidence limits were set at 3% of the mean value. If the sample size obtained from the calculation was less than 5, then no further analysis of that component for that group was done. If the sample size obtained from the equation was greater than 5, then analysis as well as recalculation of the required sample size was carried out until 10 individual samples had been analysed or the calculated sample size was less than the number of determinations made.

All data analysis was carried out using the computer services of the University of Alberta. Descriptive statistics (mean, standard error and standard deviation) as well as simple linear regression, correlation and analysis of variance were conducted using MTS software (SPSS; Statistical Package for the Social Sciences). Mean values were compared using the Duncan's multiple range test. Significant differences of means were accepted at the $p<0.05$ level.

III. Results

Annulus formation of perch from Lac Ste. Anne was completed between May 1 and June 1; therefore May 15 was designated as the beginning of the next year of life. Although data was collected from March 1976 to July 1977, body and gonad growth were examined over one year of life (June 1976–June 1977) only.

A. Body Growth

Body growth of 1+ perch and 2+ males began in June and ceased in mid-winter (January–March). The larger increases in standard body length and total body weight took place in June and between October and January for 1+ perch and in July and between October and January for 2+ males. Growth, in length and weight, of 2+ females occurred mostly between June and October although body weight increased until March.

Standard body length and total body weight of 1+ males increased 26% (13 mm) and 153% (2.5 g) respectively in June and 21% (15 mm) and 79% (4.1 g) respectively between October and January (Fig. 1 and 2; Appendix Tables 2 and 3). Standard length of 2+ males increased by 9% (8 mm) in July and by 13% (13 mm) between October and January (Fig. 1, Appendix Table 2). Total body weight for 2+ males increased by 40% (4.2 g) in July and 38% (6.6 g) between October and

FIGURE 1. Standard body length of male yellow perch at Lac Ste. Anne. Mean ± SE. Circles - 2+ males; triangles - 1+ males. Points with no confidence limits shown represent mean values with confidence limits narrower than the width of the symbol used to illustrate the mean values. Means from different sampling periods are compared by Duncan's multiple range test. MA_2 - March 1977; JE_2 - June 1977. Means underlined at the same level are not significantly different ($p < 0.05$).

Range Test - 1+

$$\begin{array}{cccccccc} \text{JE} & \text{JU} & \text{AU} & \text{SE} & \text{JE}_2 & \text{OC} & \text{JA} & \text{MA}_2 \\ \cline{2-3} \cline{4-6} \end{array}$$

Range Test - 2+

$$\begin{array}{cccccccc} \text{JE} & \text{JU} & \text{AU} & \text{SE} & \text{OC} & \text{JE}_2 & \text{MA}_2 & \text{JA} \\ \cline{1-2} \cline{3-4} \\ \cline{4-7} \\ \cline{7-8} \end{array}$$

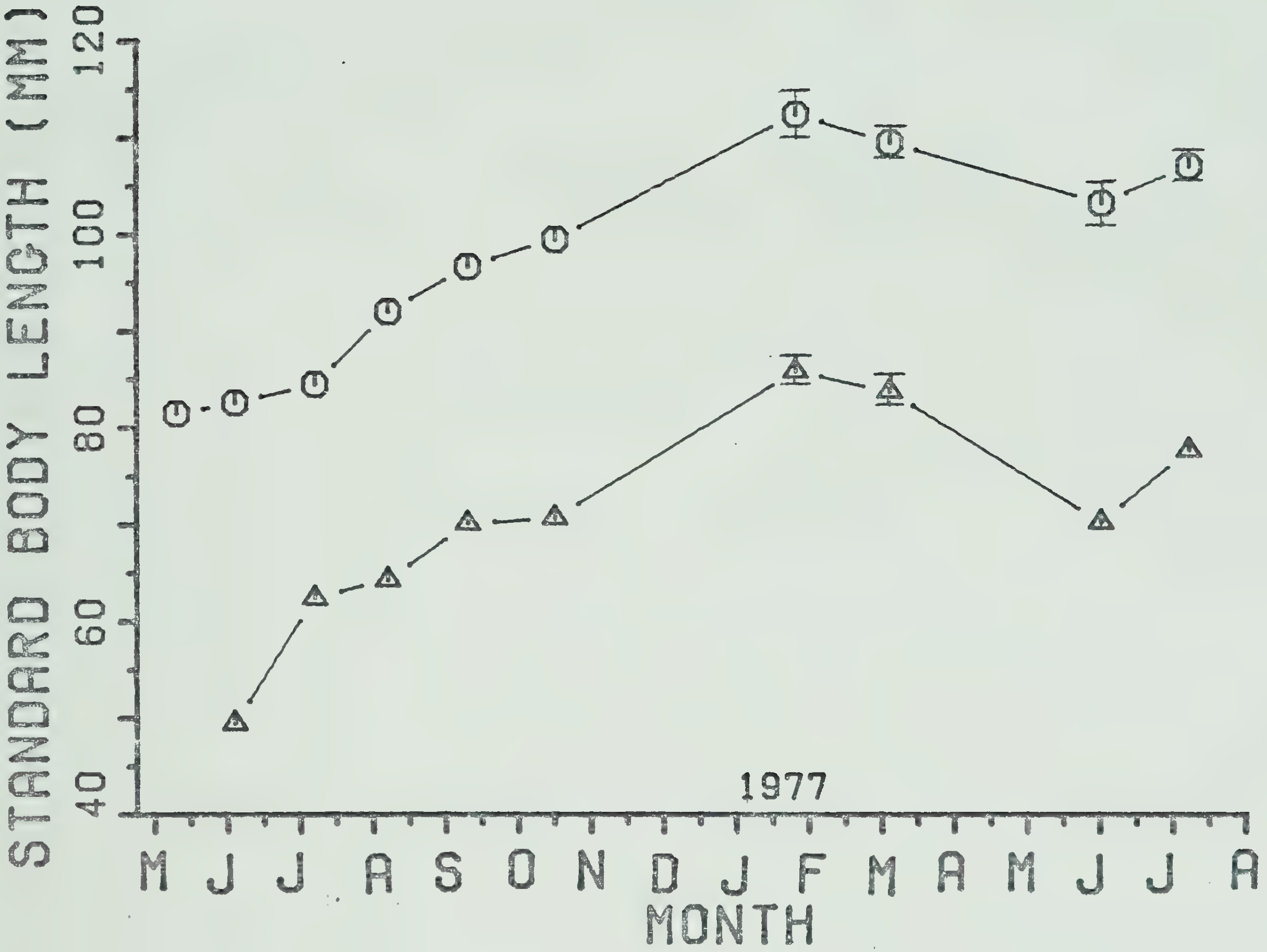

STANDARD BODY LENGTH (MM)
40
60
80
100
120
1977
M J J A S O N D J F M A M J J A
MONTH

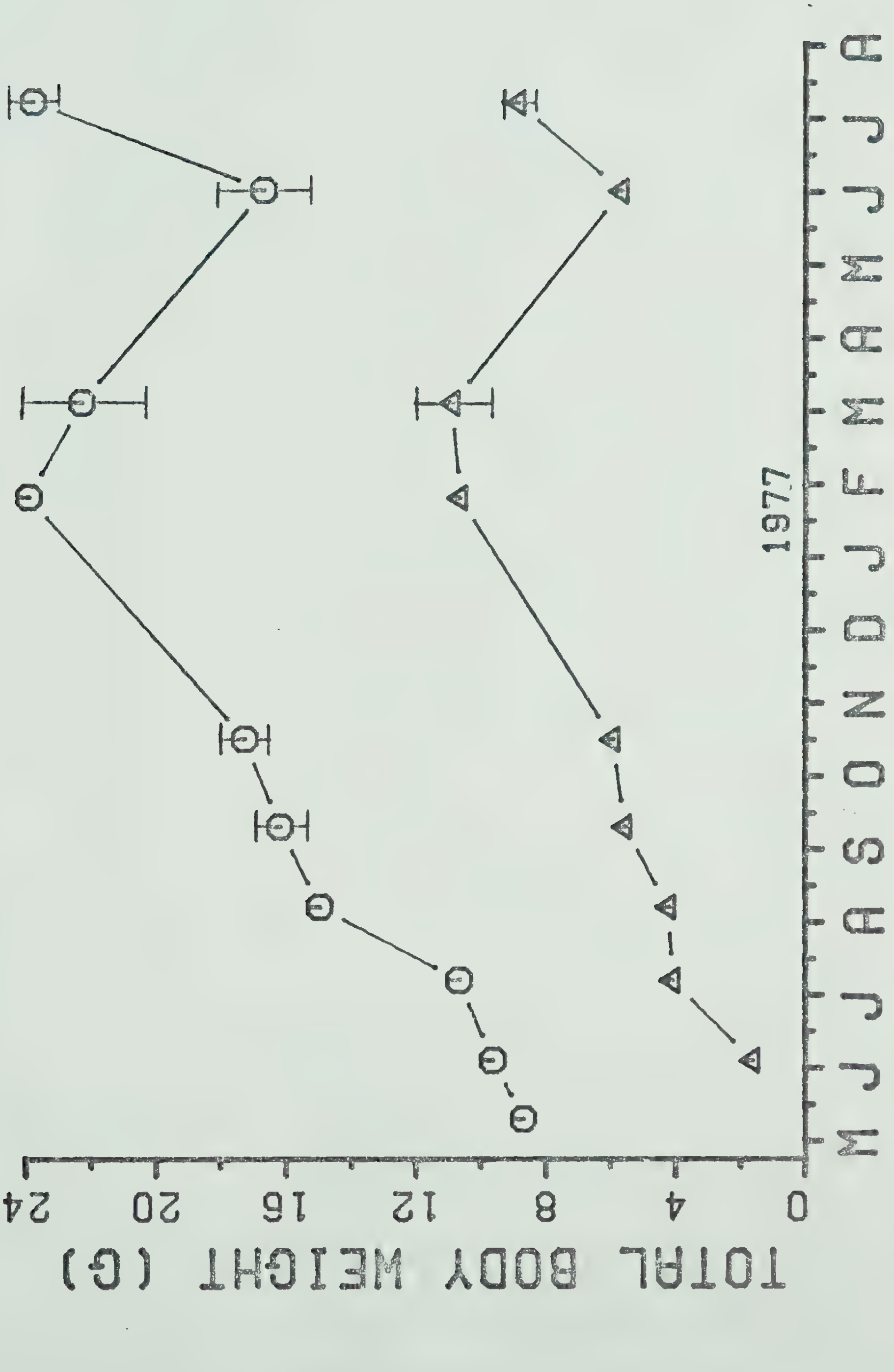
FIGURE 2. Total body weight for male yellow perch. Mean ± 1 SE. Circles - 2+ males; triangles - 1+ males. Statistical representation as in Figure 1.

Range Test - 1+

JE $\underline{\text{JU AU}}$ $\underline{\text{SE JE}_2\text{ OC}}$ $\underline{\text{JA MA}_2}$

Range Test - 2+

$\underline{\text{JE JU}}$ $\underline{\text{AU SE JE}_2\text{ OC}}$ $\underline{\text{MA}_2\text{ JA}}$


TOTAL BODY WEIGHT (G)
0
4
8
12
16
20
24
M J J A S O N D J F M A M J J A
1977
MONTH

January (Fig. 2; Appendix Table 3).

One+ males showed a greater increase in standard length (34 mm, 69%) between June 1976 and January 1977 than did 2+ males (27 mm, 34%) (Fig. 1). The percent increase from June 1976 to March 1977, in total body weight, was larger in 1+ males than in 2+ males (573.0% and 131.5% respectively) although the absolute increase in weight was larger in 2+ males (12.4 g 2+; 9.2 g 1+) (Fig. 2).

One+ females grew 140% (2.4 g) and 25% (12 mm) in weight and length respectively during June and 171% (9.7 g) and 31% (22 mm) in weight and length between October and January (Figs. 3 and 4, Appendix Tables 2 and 3). Two+ females increased 21.5 g (191%) in total body weight between June and October (Fig. 4, Appendix Table 3). The largest increase in total body weight occurred during September (11.6 g, 56%) while the largest increase in standard length took place in August (18 mm, 18%). Between June 1976 and January 1976 1+ female perch increased 42 mm (84%) in standard length and 2+ females increased by 37 mm (42%). One+ females grew 13.7 g (812%) in total body weight while 2+ females increased 22.7 g (202%).

Total body weight increased between June and January in 1+ females and between June and March in 1+ and 2+ males and 2+ females. Forty-three percent of the increase in total body weight for 1+ males occurred between June and September and 52% of the increase in total body weight of 2+ males occurred between June and September. One+ female perch

FIGURE 3. Standard body length of female yellow perch at Lac Ste. Anne. Mean ± 1 SE. Circles - 2+ females; triangles - 1+ females. Statistical representation as in Figure 1.

Range Test - 1+

$\text{JE}\quad\text{JU}\quad\underline{\text{AU}\quad\text{SE}}\quad\underline{\text{OC}\quad\text{JE}_2}\quad\text{JA}$

Range Test - 2+

$\text{JE}\quad\text{JU}\quad\text{AU}\quad\text{SE}\quad\underline{\text{OC}\quad\text{JE}_2\ \text{MA}_2\quad\text{JA}}$

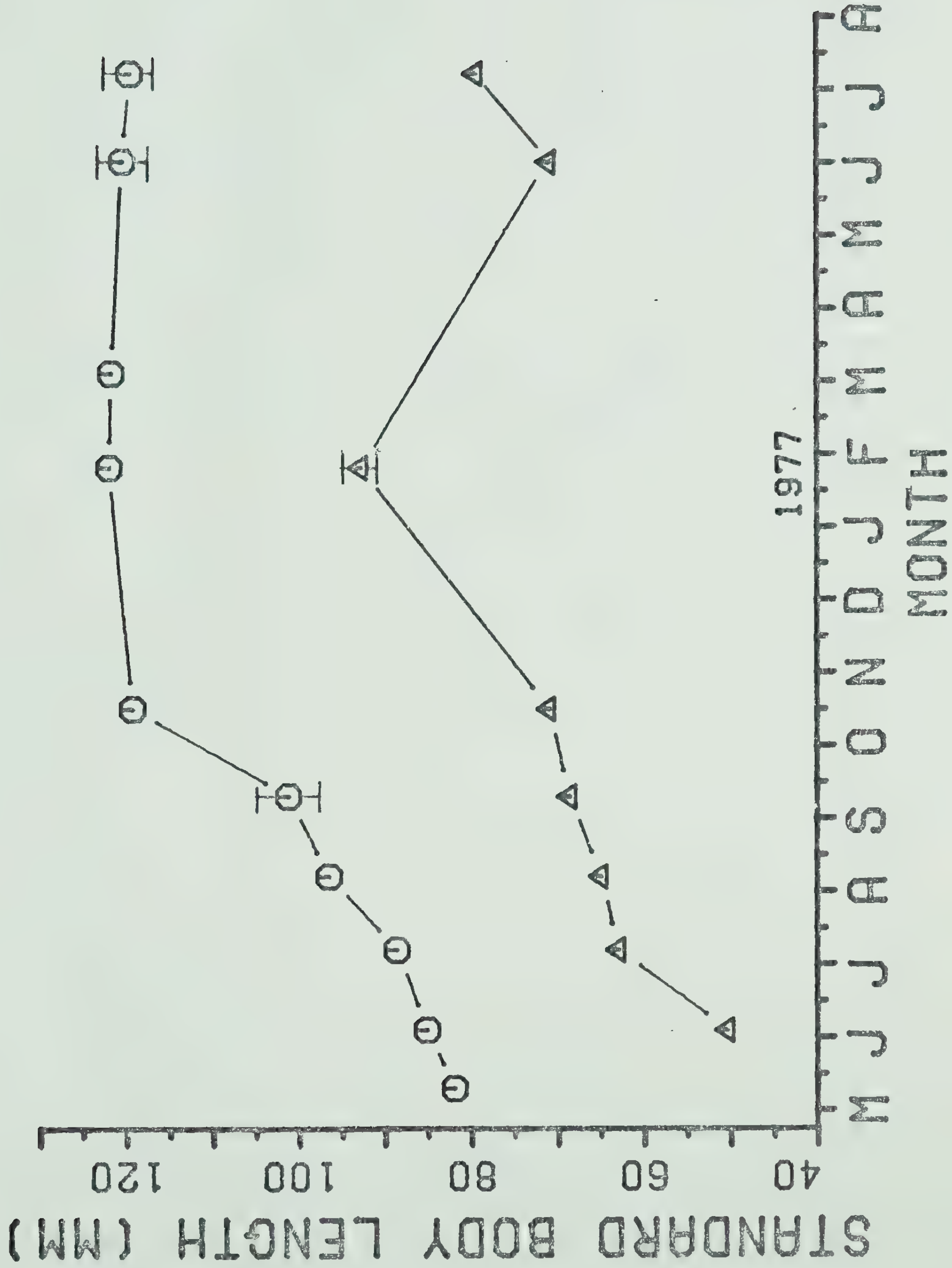
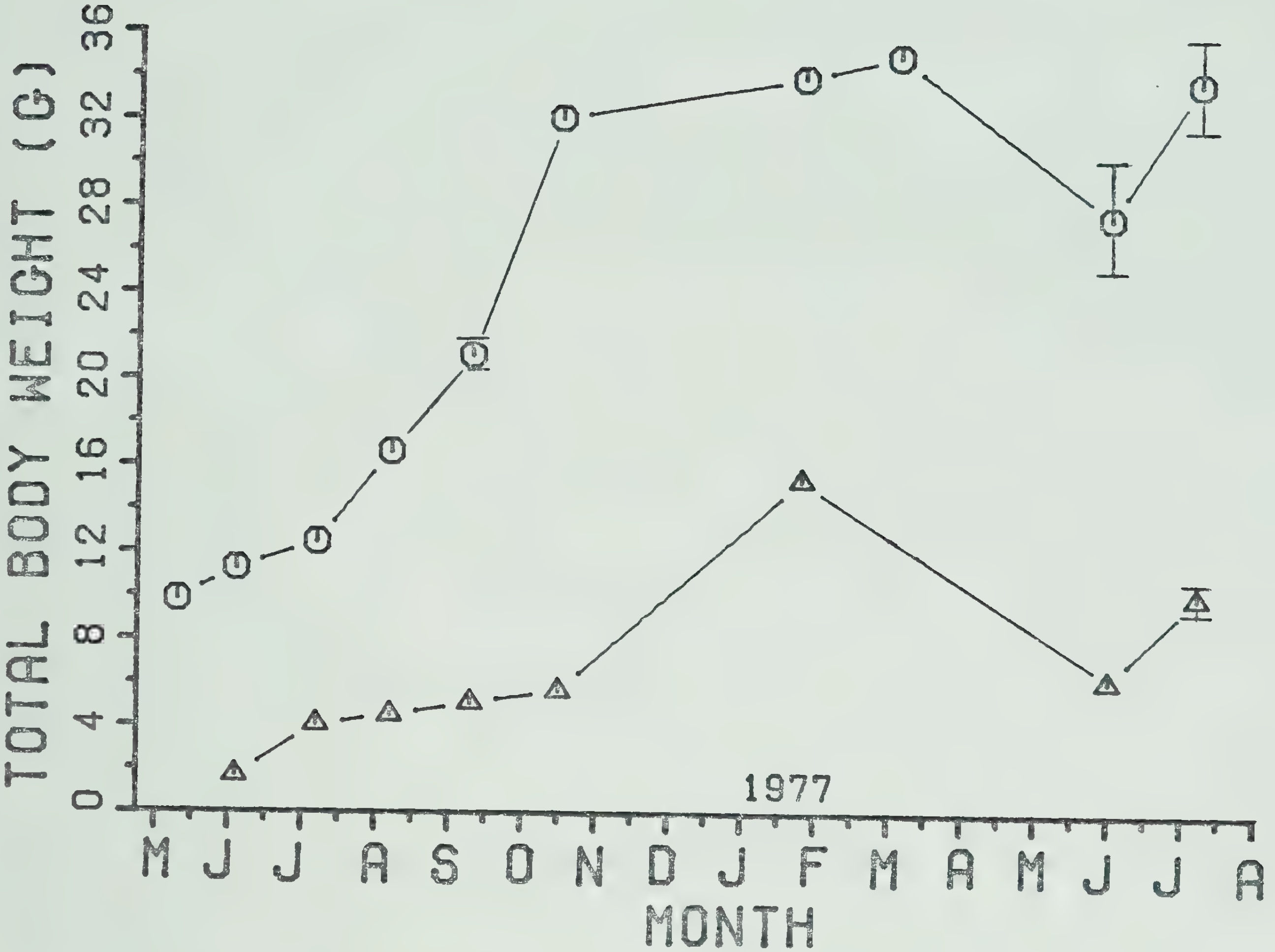

STANDARD BODY LENGTH (MM)
40
60
80
100
120
MONTH
1977
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J
A

FIGURE 4. Total body weight for female yellow perch. Mean ± 1 SE. Circles - 2+ females; triangles - 1+ females. Statistical representation as in Figure 1.

Range Test - 1+
JE JU AU SE OC JE_2 JA

Range Test - 2+
JE JU AU SE JE_2 OC JA MA_2


TOTAL BODY WEIGHT (G)
0
4
8
12
16
20
24
28
32
36
1977
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J
A
MONTH

showed 25% of the increment in total body weight between June and September. Two+ females showed 61% of the increase between September and March with 49% of the total increase in total body weight occurring during September.

Perch captured as 2+ in June 1977 were much shorter and lighter than perch captured as 2+ in June 1976 but similar in size to perch captured as 1+ in October 1976 (see Appendix Tables 2 and 3). The difference in size between January and March 1+ perch, when compared with October 1976 1+ perch and June 1977 2+ perch, may be due to sampling gear selectivity or to the absence of size groups of fish from the sampling area. October 1976 and June 1977 collections were made with gillnets, trawls, and seines, while fish were collected with gillnets only in January and March. Since perch captured as 2+ in June 1977 were smaller, condition and body composition changes of 1+ perch were examined until January for females and until March for males. One+ females were not collected in March.

Condition of 1+ perch rose dramatically in June, remained fairly constant through the summer, and increased between October and January in females and between January and March in males (Fig. 5). The condition of 2+ perch reached a peak in early fall, declined until January, and then increased until spawning in May (Fig. 6). Condition of perch from Lac Ste. Anne decreased after spawning.

FIGURE 5. Seasonal variation in condition of 1+ yellow perch. Circles - Males; triangles - females.

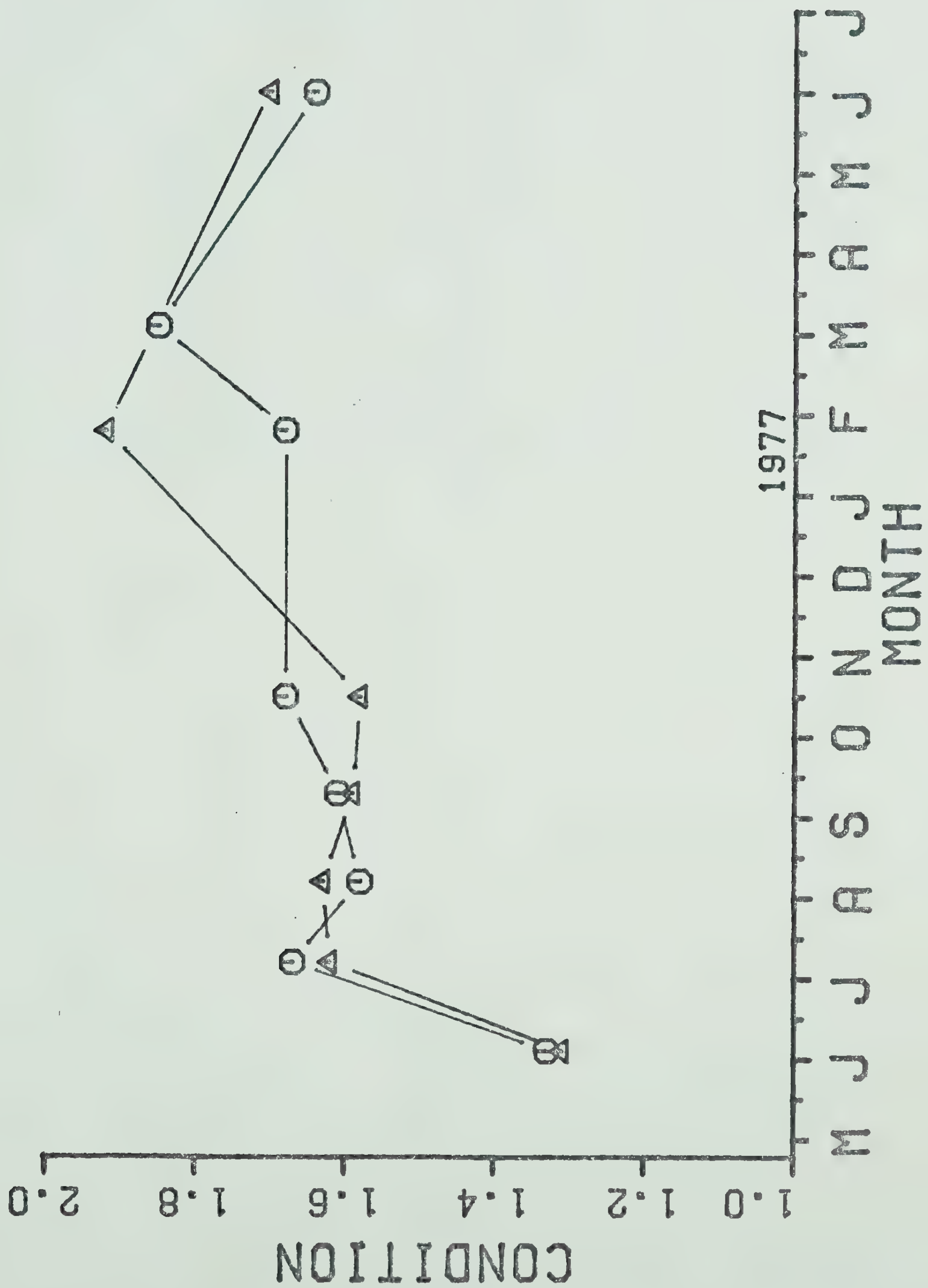
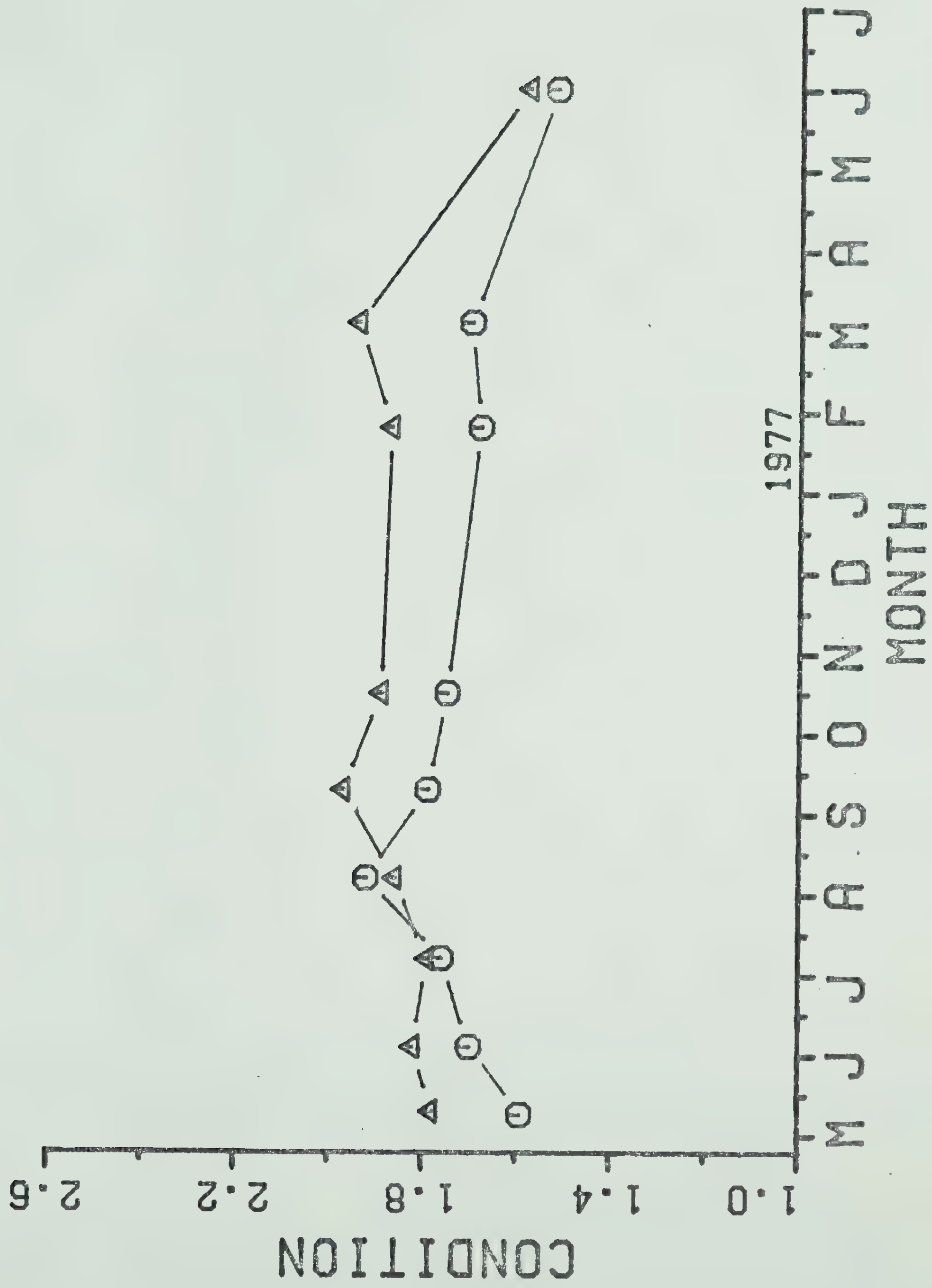

CONDITION
1.0
1.2
1.4
1.6
1.8
2.0
MONTH
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J
1977

FIGURE 6. Seasonal variation in condition of 2+ perch. Circles - males; triangles - females.


CONDITION
1.0
1.4
1.8
2.2
2.6
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J
1977
MONTH

B. Body Protein Content

Total body protein content (g protein/fish excluding gonad) was correlated with total body weight in male ($r=0.99$; $p<0.001$) and female ($r=0.98$; $p<0.001$) perch. Increments, during sampling periods, in total body weight (see Figs. 2 and 4) and total body protein content (see Figs. 7 and 8) were correlated for 1+ males ($r=0.90$; $p<0.01$) and 1+ females ($r=0.99$; $p<0.01$). The larger increases in total body protein content of perch from Lac Ste. Anne occurred during the months of greater increase in body length and body weight.

The largest increase in total body protein content of 1+ males occurred during June (0.48 g, 171%) (Fig. 7; Appendix Table 4). Total body protein content of 1+ female perch increased 82% (0.28 g) in June and 207% (1.99 g) between October and January (Fig. 8; Appendix Table 4).

Total body protein content of 2+ males increased 44% (1.64 g) between June and October (Fig. 7; Appendix Table 4). The more rapid increases in total body protein content occurred in June (28%, 0.41 g) and July (35%, 0.65 g). Total body protein content rose to a maximum of 4.80 g in March 1977 and decreased significantly to 2.83 g in June 1977.

Total body protein content of 2+ females showed increases averaging 34% per month between June and October (Fig. 8; Appendix Table 4). A large decrease in total body protein content occurred between October and January (19%,

FIGURE 7. Total body protein content of males at time of collection. Mean ± 1 SE. Circles - 2+ males; triangles - 1+ males. Statistical representation as in Figure 1.

Range Test - 1+

JE JU AU JE_2 OC SE JA MA_2

Range Test - 2+

JE JU AU JE_2 SE OC JA MA_2

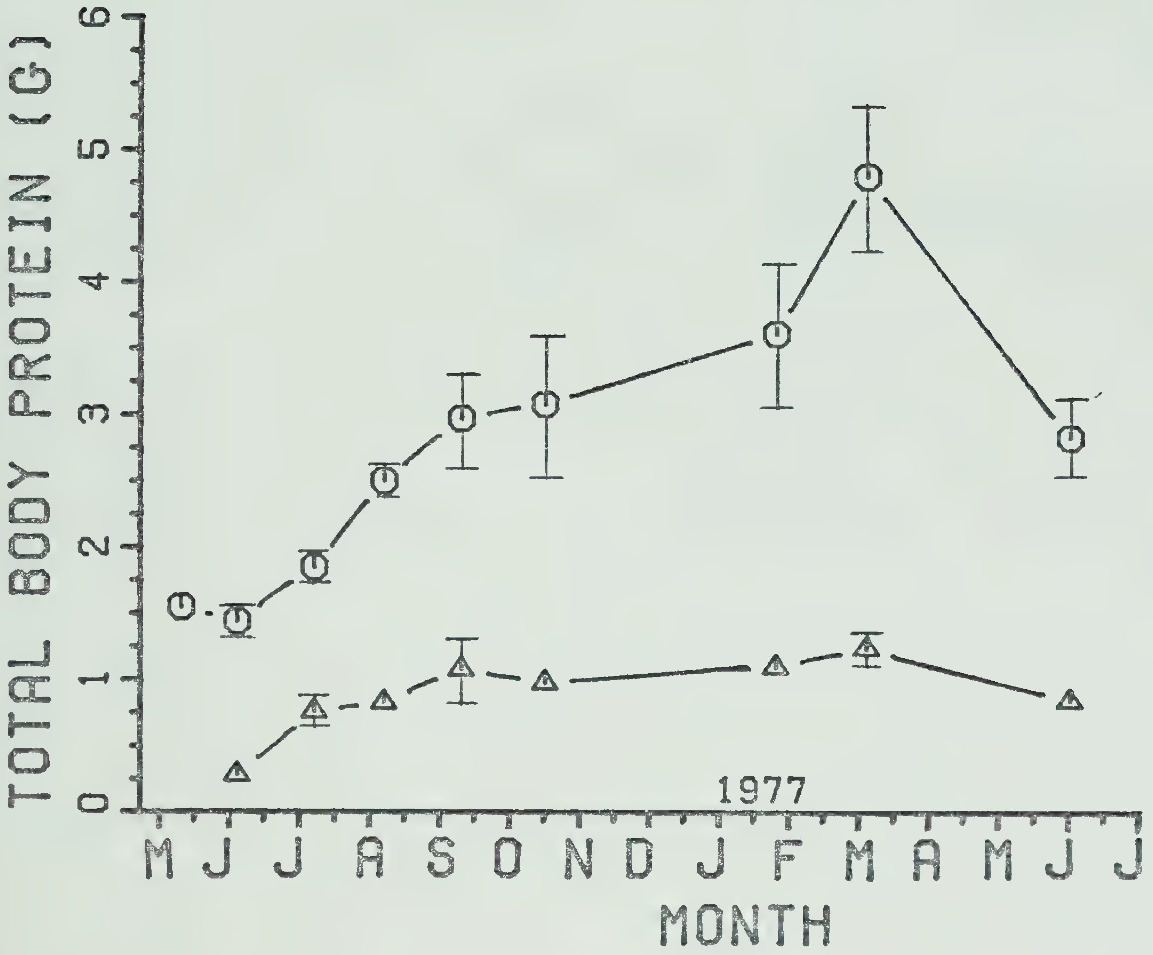

TOTAL BODY PROTEIN (G)
0
1
2
3
4
5
6
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J
1977
MONTH

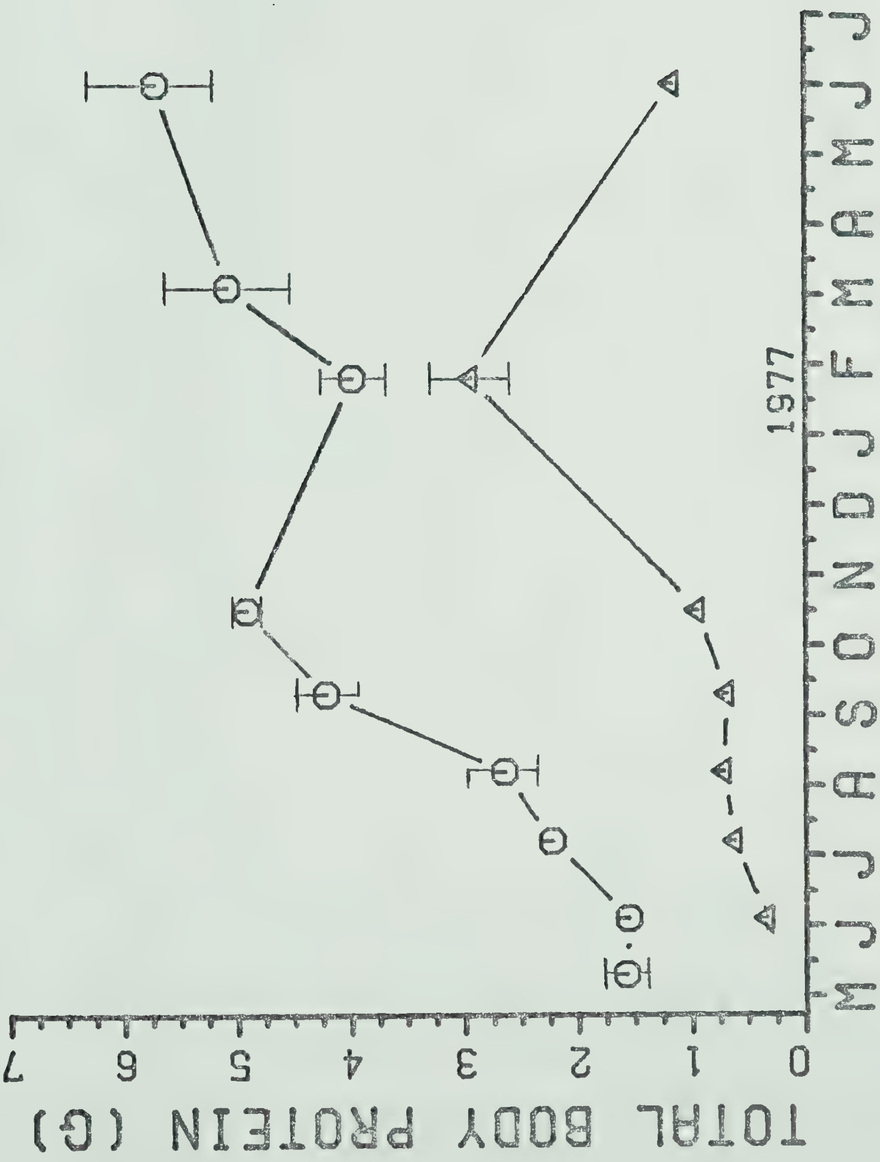
FIGURE 8. Total body protein content of females at time of collection. Mean ± 1 SE. Circles - 2+ females; triangles - 1+ females. Statistical representation as in Figure 1.

Range Test - 1+

JE JU SE AU OC JE_2 JA

Range Test - 2+

JE JU AU JA SE OC MA_2 JE_2


TOTAL BODY PROTEIN (G)
0
1
2
3
4
5
6
7
M
J
J
A
S
O
N
D
J
F
M
A
M
J
1977
MONTH

0.94 g) when body weight increased slowly and when gonad weight increased from 1.26 g to 2.52 g (Fig. 16). Total body protein content increased by 40% from January to a peak value of 5.70 g in June 1977 while little body growth occurred.

C. Body Water Content

Body water content of perch from Lac Ste. Anne generally decreased over the summer and increased over the winter. Changes in body water content were greater in 2+ perch. Increments, during sampling periods, in total body water content (see Appendix Table 6) (g H_2O/fish excluding gonad) and total body weight (see Figs. 2 and 4) were correlated in 1+ females (r=1.00; $p<0.01$), 2+ males (r=0.96; $p<0.01$) and 2+ females (r=0.93; $p<0.01$).

The body water content (g H_2O/100 g wet body weight) of 1+ perch did not change significantly between June and September (Figs. 9 and 10; Appendix Table 5). Large significant increases in body water took place during September (1.19 % H_2O male, 1.16% H_2O female) and between October and January (0.92% H_2O male, 0.74% H_2O female).

Body water content of 2+ perch decreased from June to August, increased to January and then decreased until June (Fig. 9; Appendix Table 5). Body water contents of these fish were lowest in August and highest in January.

Total body water content (Appendix Table 6) accounted

FIGURE 9. Seasonal variation in body water content of males. Mean ± 1 SE. Circles - 2+ males; triangles - 1+ males. Statistical representation as in Figure 1.

Range Test - 1+

$\underline{\text{AU JU JE SE}}$ OC $\underline{\text{MA}_2\ \text{JA}\ \text{JE}_2}$

Range Test - 2+

AU $\underline{\text{JE}_2\ \text{SE}\ \text{JU}}$ $\underline{\text{JE}\ \text{OC}}$ $\underline{\text{MA}_2\ \text{JA}}$

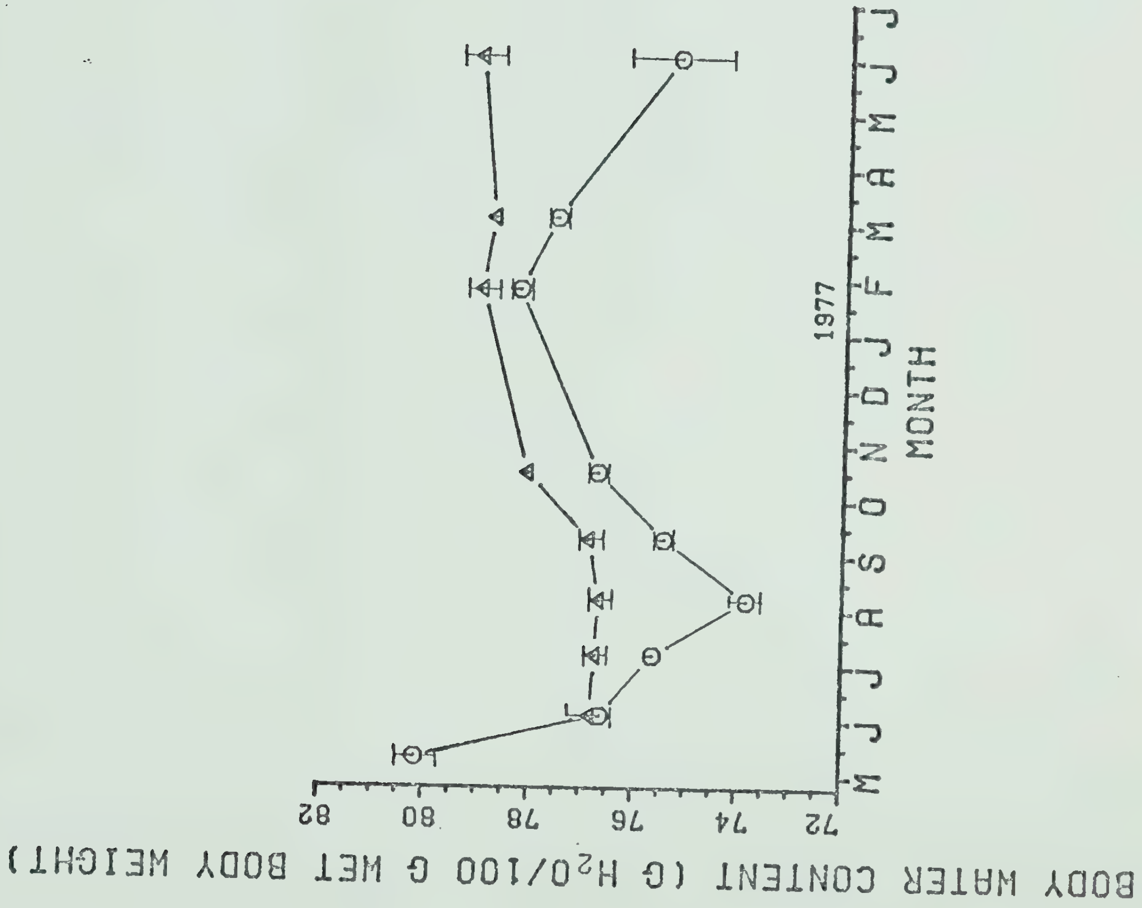

BODY WATER CONTENT (G H_2O/100 G WET BODY WEIGHT)
72
74
76
78
80
82
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J
1977
MONTH

FIGURE 10. Seasonal variation in body water content of females. Mean ± 1 SE. Circles - 2+ females; triangles - 1+ females. Statistical representation as in Figure 1.

Range Test - 1+

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JE    SE    AU    JU    JE2   OC    JA2
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            ---------------
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                              ---------
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Range Test - 2+

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AU    SE    JE2   JU    JE    OC    MA2   JA
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            -------------------------
                              ----------------
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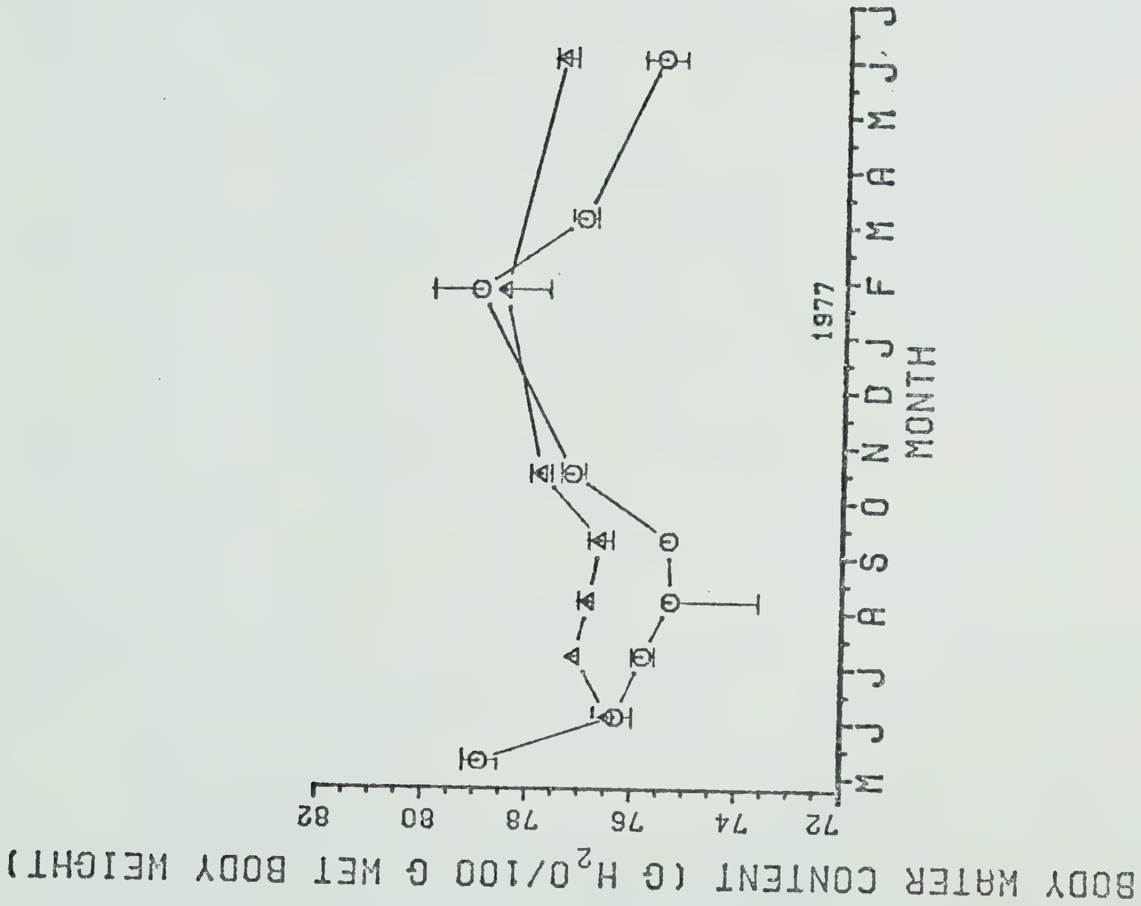
BODY WATER CONTENT (G H_2O/100 G WET BODY WEIGHT)
72
74
76
78
80
82
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J
1977
MONTH

for different proportions of the increase in body weight at different times of the year. Between June 1976 and March 1977, the increases in grams of body water of 1+ males accounted for 77.54±3.31% of the increases in total body weight. Water accounted for a maximum of 81.96% of the increase in body weight between January and March and a minimum of 63.00% of the increase in total body weight in September. In 1+ females, water accounted for 77.54±3.31% of the increases in total body weight occurring between June and January. Water accounted for a maximum 82.06% of the increase in total body weight taking place in September and a minimum of 73.94% of the August increase in body weight.

For 2+ males, water accounted for 74.10±20.10% of the additions in total body weight occurring between June 1976 and June 1977. Water accounted for a maximum of 102.13% of the increase in body weight occurring in September and a minimum of 43.05% of the increase in total body weight which took place between January and March. Body water contents were responsible for 71.29±9.02% of the changes in total body weight which took place in 2+ females between June 1976 and June 1977. Water contributed a maximum of 83.72% of the increase in total body weight which occurred in September and a minimum of 57.44% of the increase in total body weight which occurred between March and June.

D. Body Fat Content

Total body fat content was correlated with total body weight for male ($r=0.75$; $p<0.001$) and female ($r=0.84$; $p<0.001$) perch. In 2+ perch only, total body fat content declined with the onset of gonad development.

The greatest increases in total body fat content of 1+ males occurred during July (0.04 g, 50%) and August (0.05 g, 42%) resulting in a peak value of 0.17 g in September (Fig. 11; Appendix Table 7). Total body fat content fell significantly to 0.11 g in October and then rose significantly by 42% to 0.16 g in March.

The total body fat content for 1+ females increased from 0.09 g in July to 0.13 g in October (Fig. 12; Appendix Table 7). The significant and largest increase in total body fat content occurred between October and January (0.12 g, 92%). One+ females showed a correlation of changes in total body fat content with changes in total body weight (see Fig. 4) ($r=0.99$; $p<0.01$).

Total body fat content of 2+ males showed marked increases over June (0.09 g, 38%) and July (0.15 g, 45%) and between January and March (0.10 g, 34%) (Fig. 11; Appendix Table 6). There was a significant decrease of 0.19 g or 40% in the body fat content between August and January while testes weight increased (see Fig. 15).

Total body fat content of 2+ females increased by 123% from 0.26 g in June to a maximum of 0.58 g in October (Fig. 12; Appendix Table 7). A dramatic drop in total body fat

FIGURE 11. Total body lipid content of males at time of collection. Mean ± 1 SE. Circles - 2+ males; circles - 1+ males. Statistical representation as in Figure 1.

Range Test - 1+

JU OC AU JA JE_2 MA_2 SE

Range Test - 2+

JE JA OC JU MA_2 JE_2 SE AU

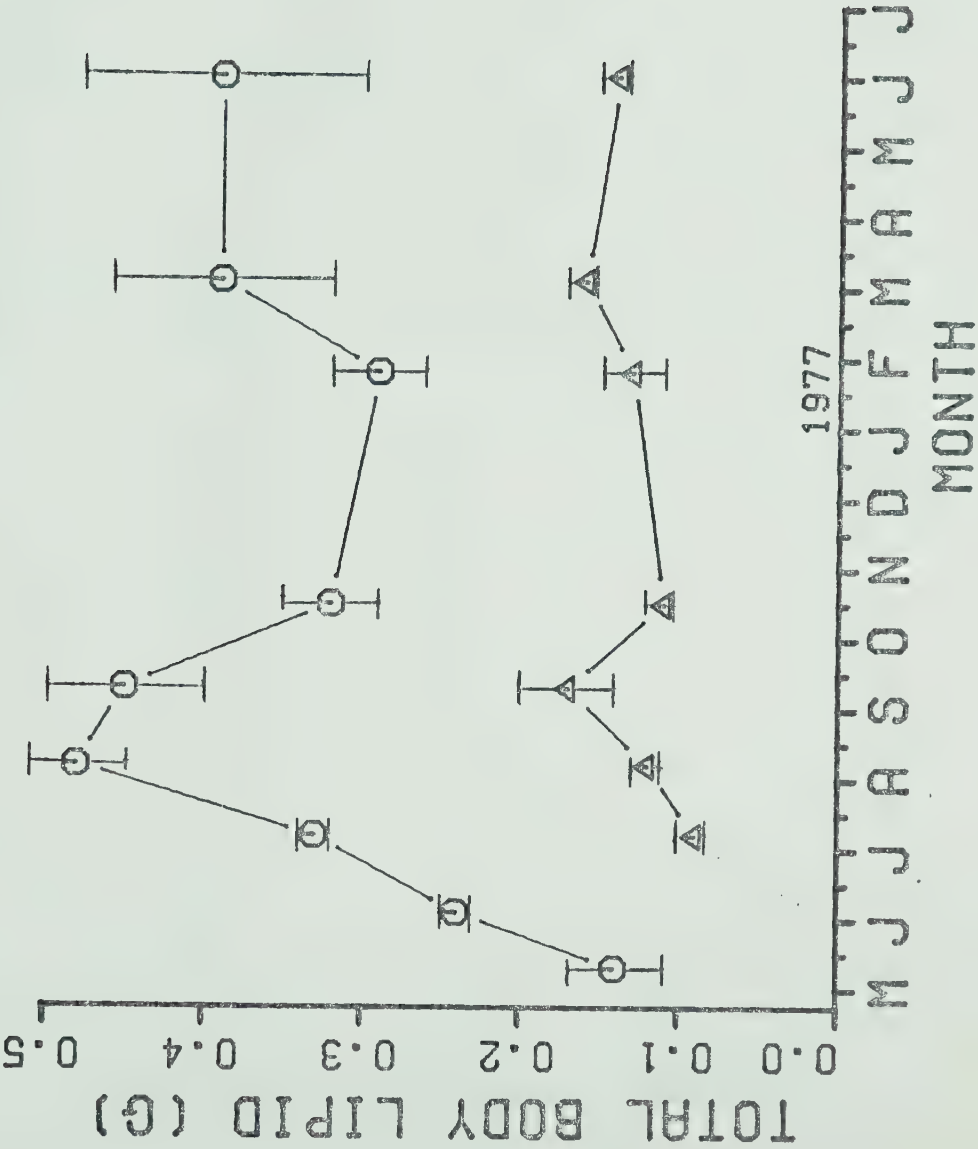
TOTAL BODY LIPID (G)
0.0
0.1
0.2
0.3
0.4
0.5
M J J A S O N D J F M A M J J
1977
MONTH

FIGURE 12. Total body lipid content of females at time of collection. Mean $\pm$ 1 SE. Circles - 2+ females; triangles - 1+ females. Statistical representation as in Figue 1.

Range Test - 1+

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JU  SE  AU  OC  JE2  JA
__________
    __________
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Range Test - 2+

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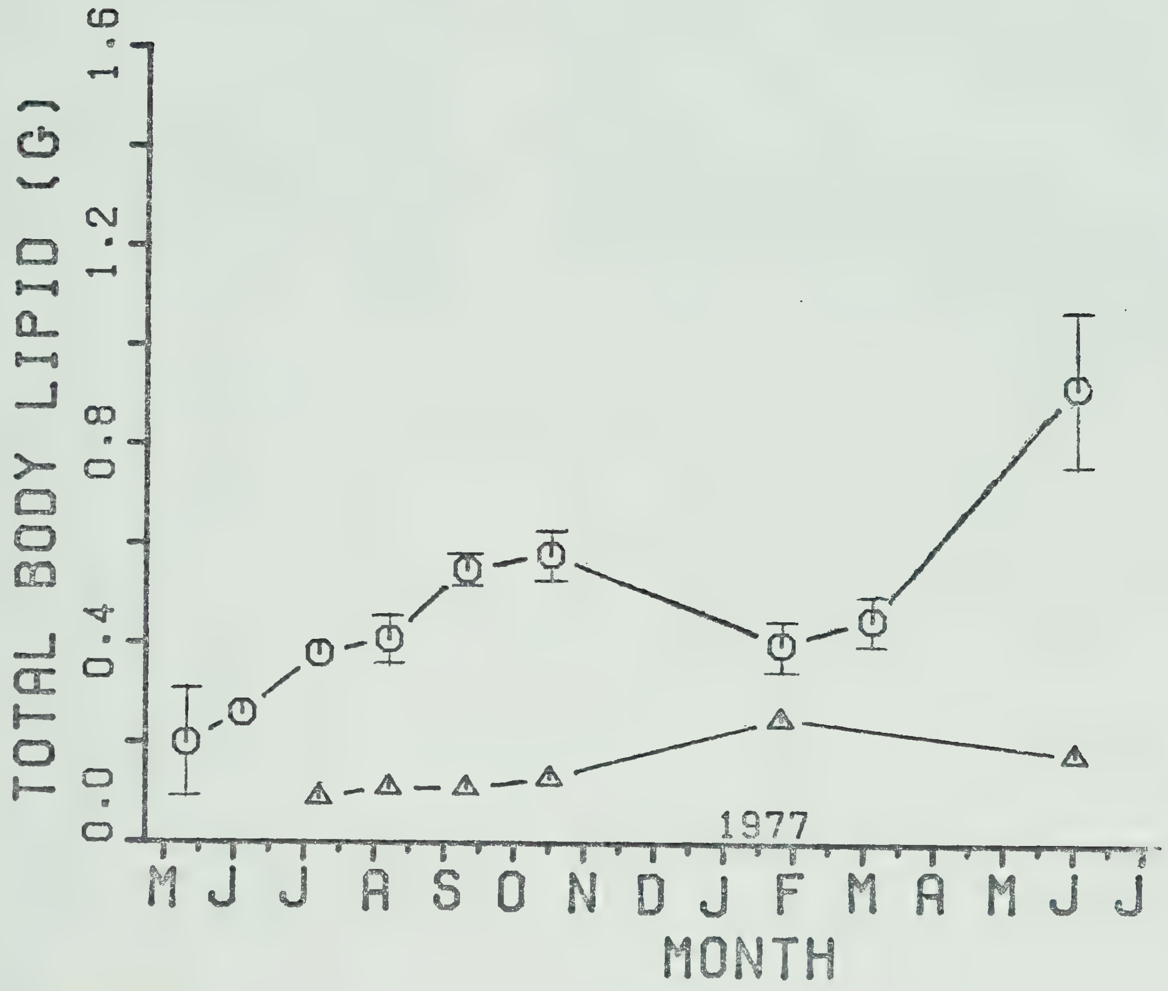
JE  JU  JA  AU  MA2  SE  OC  JE2
___________________
    ___________________
        ___________________
```


TOTAL BODY LIPID (G)
0.0
0.4
0.8
1.2
1.6
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J
1977
MONTH

content (0.18 g, 31%) took place between October and January when body growth increments declined and ovary weight increased by 200% (see Fig. 16). Total body fat content then increased to 0.92 g in June 1977 from 0.40 g in January.

When total body fat, total body protein and total body water contents were summed, they accounted for 95.60±1.95% of the total body weight increases for 1+ males between June 1976 and March 1977, for 98.64±7.47% of the increases in total body weight for 1+ females between June 1976 and January 1977, for 96.21±1.94% of the total body weight increases for 2+ males between June 1976 and June 1977 and for 95.63± 0.62% of the total body weight increases for 2+ females between June 1976 and June 1977.

E. Somatic Energy Content

Total somatic energy (kcal/fish excluding gonad) content was correlated with total body weight in male ($r=0.96$; $p<0.001$) and female ($r=0.96$; $p<0.001$) perch. Changes in total somatic energy content and total body weight, between sampling periods, were correlated in 1+ males ($r=0.86$; $p<0.05$) (see Figs. 2 and 13) and 1+ females ($r=0.83$; $p<0.05$) (see Figs. 4 and 14).

Total somatic energy content of 1+ males increased from July to January (Fig. 13, Appendix Table 8). The significant and greatest increase in total somatic energy

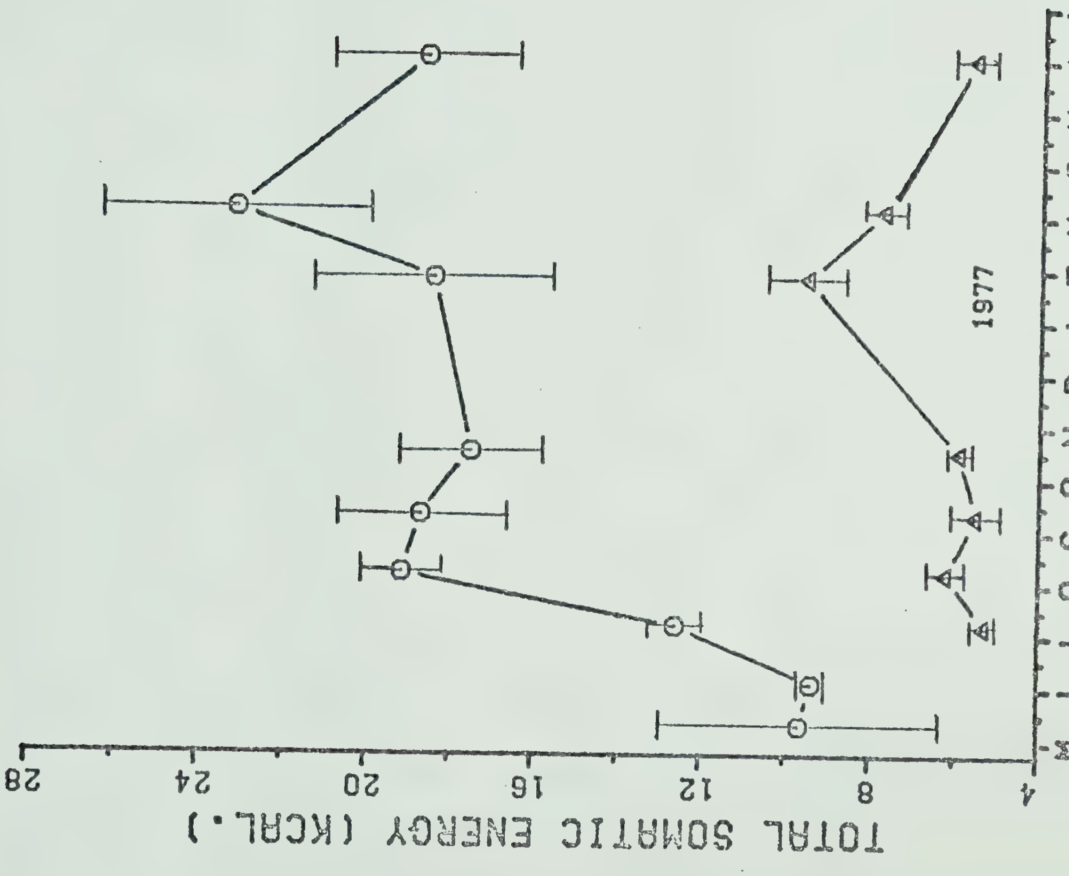
FIGURE 13. Total somatic energy content of males at time of collection. Mean ± 1 SE. Circles - 2+ males; triangles - 1+ males. Statistical representation as in Figure 1.

Range Test - 1+

JU SE JE_2 OC AU MA_2 JA

Range Test - 2+

JE JU OC JA JE_2 SE AU MA_2


TOTAL SOMATIC ENERGY (KCAL.)
4
8
12
16
20
24
28
M J J A S O N D J F M A M J J
MONTH
1977

content occurred between October and January (3.6 kcal., 61.2%).

Changes in total somatic energy content in 1+ females were similar to those shown by 1+ males although the increase in total somatic energy content of the females (11.3 kcal., 217.0%) was much greater between October and January (Fig. 14; Appendix Table 8). Total somatic energy content for 1+ females increased over July (1.1 kcal, 22.3%) and decreased during August (0.8 kcal, 14.7%).

Total somatic energy content of 2+ males showed large increases between June and August (9.8 kcal, 104.4%) and between January and March (4.7 kcal, 25.5%) (Fig. 13; Appendix Table 8). The decrease in total somatic energy content between August and October (1.6 kcal, 8.6%) occurred when total body fat content was decreasing and gonad wet weight was increasing. Total somatic energy content declined from the peak value of 23.1 kcal. in March 1977 to 18.7 kcal. in June 1977 while total body weight and total body protein content decreased. There was no significant change in total somatic energy content between August 1976 and June 1977.

Two+ females showed a large increase in total somatic energy content from 10.4 kcal. in June to a peak value of 29.4 kcal. in October (Fig. 14; Appendix Table 8). Total kilocalories then declined by 5.8 (19.6%) to 23.6 kcal. between October and January while the only decreases in total body fat and protein contents took place. The sharp

FIGURE 14. Total somatic energy content of females at time of collection. Mean ± 1 SE. Circles - 2+ females; triangles - 1+ females. Statistical representation as in Figure 1.

Range Test - 1+

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JU  SE  OC  AU  JE2  JA
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Range Test - 2+

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JE  JU  AU  JA  SE  MA2  OC  JE2
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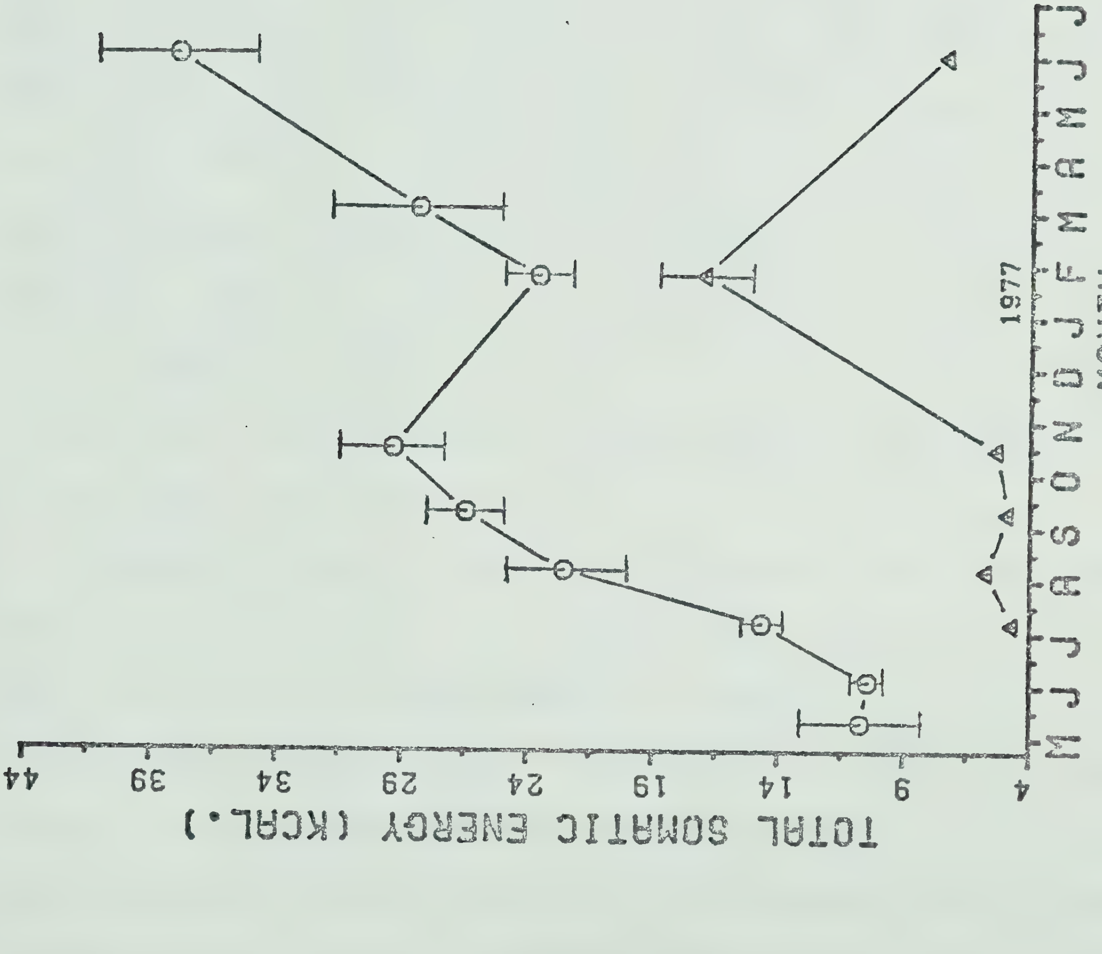

TOTAL SOMATIC ENERGY (KCAL.)
4
9
14
19
24
29
34
39
44
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J
1977
MONTH

increase in total somatic energy content, between January and June 1977 (14.4 kcal, 60.9%) occurred with little change in total body weight or standard body length but with a 104% increase in total body fat content and a 44% increase in total body protein content. Total somatic energy contents did not change significantly between August and March.

When total body fat and total body protein contents were multiplied by their calorific equivalents (Kleiber, 1975) and summed, they accounted for 106.01±20.97% of the total somatic energy contents for 1+ males between June 1976 and March 1977, for 105.23±13.22% of the total somatic energy contents between June and January for 1+ females, for 114.42±11.51% of the total somatic energy contents for 2+ males between June 1976 and June 1977 and for 108.47±10.24% of the total somatic energy contents for 2+ female perch between June 1976 and June 1977.

Changes in total somatic energy content and total body weight were correlated for 1+ perch only. This may be a result of the closer involvement, in these fish, of protein with changes in body weight. Asynchrony of changes in body fat and protein contents with changes in body energy content occurred during August, September, and January for 1+ males. These changes, as well as the non-proportional changes in body components with somatic energy content which occurred in other groups at various times, could have resulted from changes in the ash and/or carbohydrate content of the body. Body content of these components was not determined.

F. Gonad Growth

Testes weight of 1+ males began rising in August and increased to 0.52 g in January, but decreased slightly to 0.46 g in March (Fig. 15; Appendix Table 9).

Testes weight for 2+ males began rising in July and showed an increase of 0.66 g (1471%) in August (Fig. 15; Appendix Table 9). Gonad weight increased at a slower and constant rate from September to 1.20 g in March.

Ovary weight of 2+ females began increasing in July. The most rapid increase in gonad weight took place in September (0.95 g, 304%) (Fig. 16; Appendix Table 9). Gonad weight continued increasing through March, at least, when the female ovary weighed 4.20 g.

G. Gonad Composition

Most of the fat and protein were deposited in the 1+ male gonad between January and March while the 2+ males deposited fat and protein in the testes steadily from September through March. Protein and lipid were deposited in the 2+ female gonad mostly between September and January.

(Discussion of gonad composition of 1+ female perch was not considered since gonads large enough to analyse were obtained in January 1977 only.)

Total gonad protein increased continually in the 2+ males from 0.11 g in September to 0.27 g in March whereas

FIGURE 15. Testes weight at time of collection. Mean ± 1 SE. Circles - 2+ males; triangles - 1+ males. Statistical representation as in Figure 1.

Range Test - 1+

$\underline{\text{JE}\quad\text{JU}\quad\text{AU}\quad\text{JE}_2}\quad\underline{\text{OC}\quad\text{SE}}\quad\underline{\text{MA}_2\quad\text{JA}}$

Range Test - 2+

$\underline{\text{JU}\quad\text{JE}_2\quad\text{AU}\quad\text{JE}}\quad\underline{\text{OC}\quad\text{SE}\quad\text{JA}}\quad\text{MA}_2$

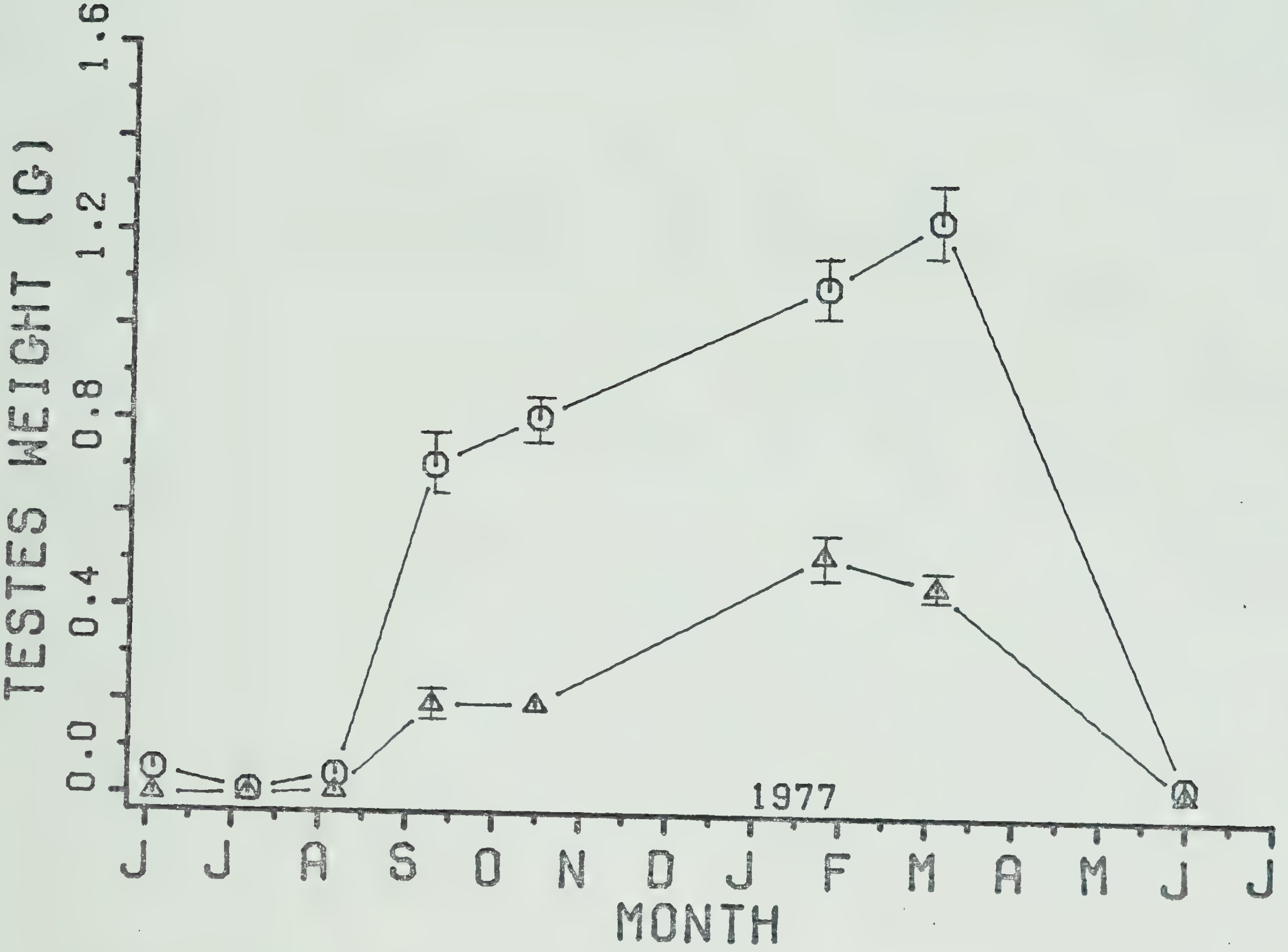

TESTES WEIGHT (G)
0.0
0.4
0.8
1.2
1.6
J
J
A
S
O
N
D
J
F
M
A
M
J
J
1977
MONTH

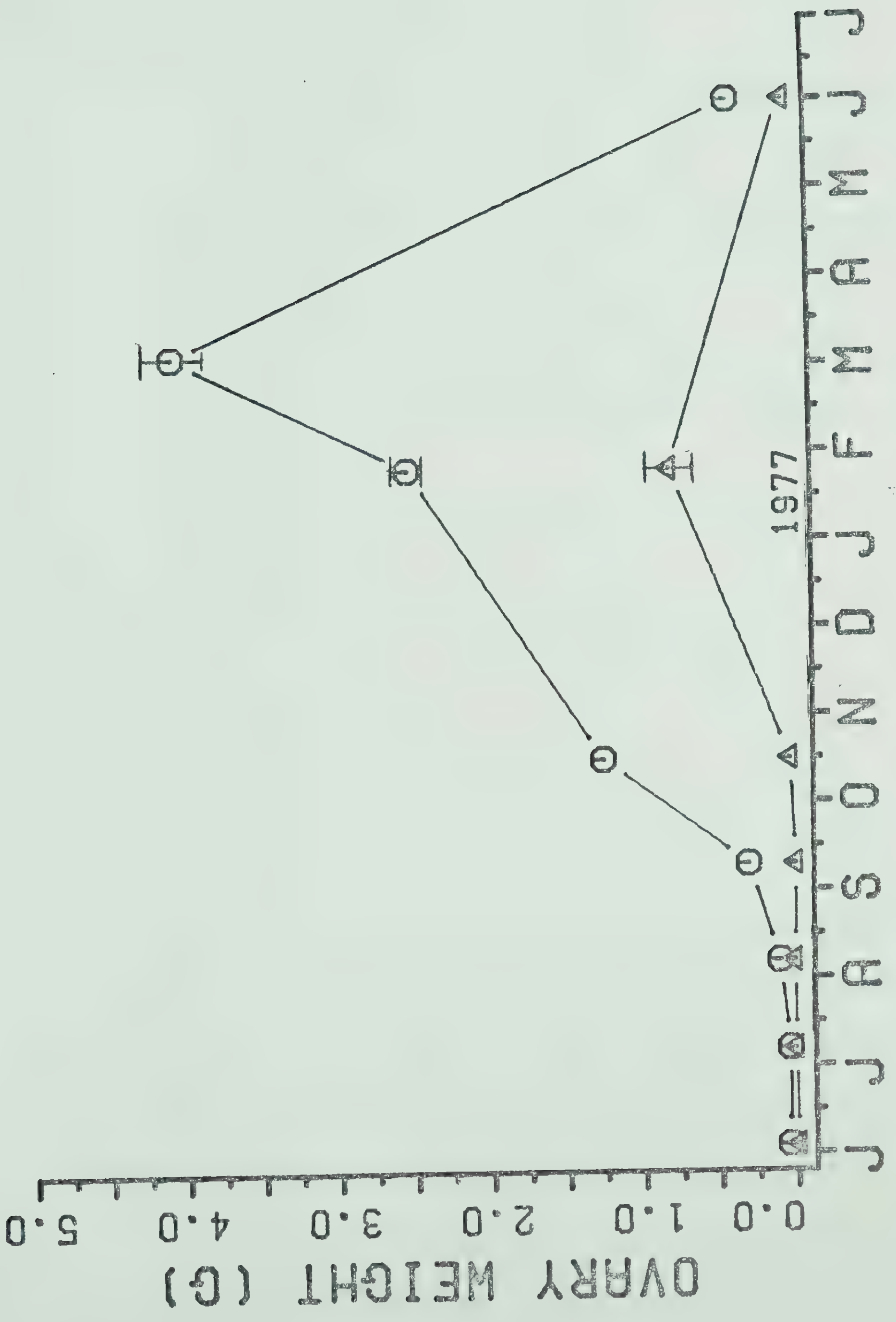
FIGURE 16. Ovary weight at time of collection. Mean ± 1 SE. Circles - 2+ females; triangles - 1+ females. Statistical representation as in Figure 1.

Range Test - 1+

$\underline{\text{JE SE JU AU JE}_2\text{ OC}}$ JA

Range Test - 2+

$\underline{\text{JE JU AU JE}_2\text{ SE}}$ OC JA MA_2


OVARY WEIGHT (G)
0.0
1.0
2.0
3.0
4.0
5.0
J
J
A
S
O
N
D
J
F
M
A
M
J
J
1977
MONTH

the 1+ male testes did not show significant protein growth until January (Table 1). Total testes protein content increased rapidly between October and January (43%) and between January and March (35%) in 2+ males and between September and March (100%) in 1+ males.

Total gonad fat did not change significantly between September and March in 2+ males while, in 1+ males, total gonad fat content increased significantly between January and March (Table 1). Total testes fat content increased most rapidly (93%) between October and January in 2+ males and rapidly in September (100%) and between January and March (92%) in 1+ males.

Gonad water content of males did not change significantly between September and March (Table 1). Only total testes protein content ($r=0.80$; $p<0.001$) was significantly correlated with increases in gonad wet weight for 1+ and 2+ males (see Table 1 and Appendix Table 9).

Ovary protein of 2+ females increased from 0.07 g in September to 0.43 g in March (Table 1). The increase in total gonad protein between October (0.13 g) and January (0.34 g) was significant. Total ovary protein content increased rapidly in September (86%) and between October and January (162%). Total gonad fat content increased continually from September (0.02 g) to March (0.21 g) (Table 1). The increase between October (0.05 g) and January (0.18 g) was significant and the most rapid (246%). Gonad water content of 2+ females did not change significantly between

Table 1. Gonad water (% wet weight), protein and lipid (g/gonad) at time of collection. Mean ± 1 SE.

		1976 Sep 7-8	Oct 14-15	1977 Jan 22-23	Mar 2-3	Range Test
Water	1+ male	85.68±1.54	78.04±1.24	80.46±1.02	69.85±10.53	MA_2 OC JA SE
	n	5	5	6	6	
	1+ female	&&&	&&&	77.10±0.34	XXX	
	n			3		
	2+ male	81.95±2.13	81.26±3.07	77.41±0.63	78.42±0.88	JA MA_2 OC SE
	n	4	4	5	4	
	2+ female	76.38±1.37	78.96±1.56	77.07±0.52	80.02±0.48	SE JA OC MA_2
	n	5	5	5	5	
Protein	1+ male	0.06±0.02	0.04±0.003	0.06±0.01	0.12±0.04	OC JA SE MA_2
	n	10	10	10	10	
	1+ female	&&&	&&&	0.22±0.03	XXX	
	n			10		
	2+ male	0.11±0.02	0.14±0.03	0.20±0.03	0.27±0.05	SE OC JA MA_2
	n	10	10	10	10	
	2+ female	0.07±0.01	0.13±0.03	0.34±0.02	0.43±0.05	SE OC JA MA_2
	n	10	10	10	10	
Lipid	1+ male	0.005±0.002	0.010±0.001	0.010±0.001	0.025±0.008	SE OC JA MA_2
	n	10	10	10	10	
	1+ female	&&&	&&&	0.120±0.014	XXX	
	n			10		
	2+ male	0.033±0.010	0.029±0.004	0.056±0.008	0.057±0.009	OC SE JA MA_2
	n	10	10	10	10	
	2+ female	0.025±0.002	0.052±0.013	0.180±0.009	0.206±0.022	SE OC JA MA_2
	n	10	10	10	10	

X - Not Collected

& - Not Determined

MA_2 - March 1977

September and January. For 2+ females, total gonad protein content (r=0.98, p<0.001) and total gonad fat content (r=0.96, p<0.001) were significantly correlated with wet gonad weight (see Table 1 and Appendix Table 9).

Between September 1976 and March 1977, the sums of total gonad protein, total gonad fat, and total gonad water contents accounted for 104.44±5.40% of the total gonad weight for 1+ males, for 101.03 ±2.92% of the total gonad weight for 2+ males and for 96.02±1.06% of the total gonad weight for 2+ females.

Energy content of the March gonads was calculated from addition of total gonad fat content multiplied by its calorific equivalent with total gonad protein content multiplied by its calorific equivalent. The 2+ female ovary contained 4425 calories while the testes of 2+ males contained 47% less energy (2081 cal.). The 1+ male gonad contained 911 calories which was 44% less than for 2+ males. Calories of total testes fat contributed 29% of the total gonad calories for 1+ males and 30% of the total gonad calories for 2+ males . Total testes protein contributed 71% of the total gonad calories for 1+ males and 70% of the total gonad calories for 2+ males. In the 2+ female gonad, however, protein contributed 51% of the total ovary calories while gonad fat contributed 49% of the total gonad calories. Total gonad calories represented 10% and 9% of the total body energy content (total somatic energy content plus gonad energy content) for 1+ and 2+ males respectively. The 2+

perch ovary contained 14% of the total body energy content.

Male perch used body fat as a substrate for testes development whereas body fat and protein were used by 2+ females. For male perch, only body fat content (g fat/100 g wet body weight) was significantly correlated (r=-0.36, p<0.001) with gonad wet weight (see Appendix Tables 9 and 11). Body fat content (r=-0.47; p<0.001) and body protein content (g protein/100 g wet body weight) (r=-0.63; p<0.001) were significantly correlated with gonad wet weight for 2+ female perch (see Appendix Tables 9, 10 and 11). Body fat content of 1+ males decreased significantly from 2.6% in August to 1.7% in January (Appendix Table 11) and body fat content of 2+ males decreased significantly (112%) from 3.4% in August to 1.5% in January. Two+ female perch showed a significant decrease in body protein content from August (16.9%) to January (15.1%) and a significant decrease in body fat content between July (3.0%) and March (1.5%) (Appendix Tables 10 and 11).

H. Visceral Fat Content

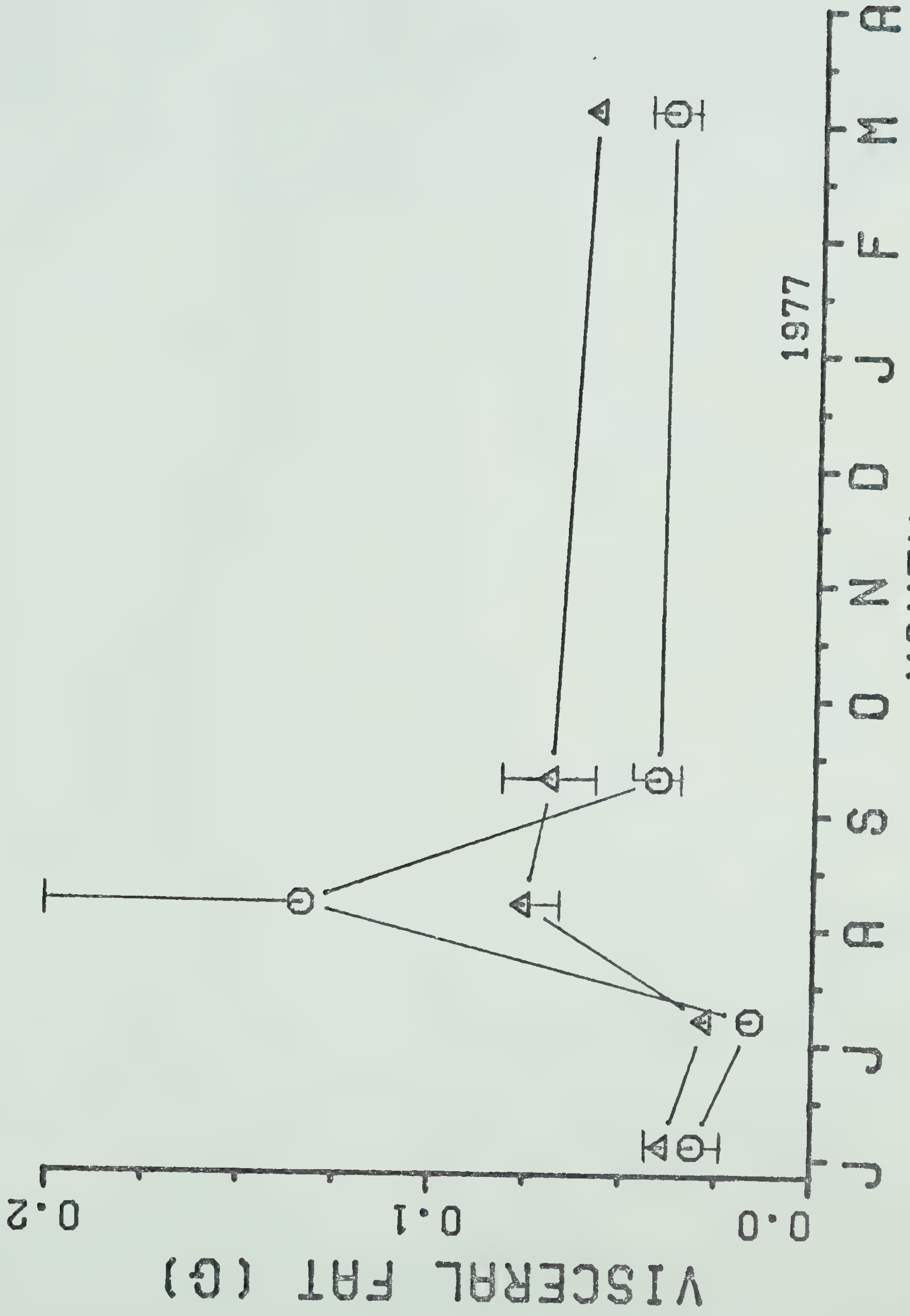
Visceral fat stores of 2+ perch were built up during July but, particularly in males, were markedly reduced in August when gonad weight increased rapidly (Fig. 17; Appendix Table 12).

In 2+ males, visceral fat increased by 737% to 0.13 g in July but then dropped by 69% to 0.04 g in September. There was no difference in visceral fat content between September and March. Fat content of the viscera of 2+ males represented a minimum of 5% of the total body fat in July and a maximum of 28% in August.

Visceral fat content of 2+ females increased by 171% during July to 0.08 g in August and decreased to 0.05 g in March. The visceral fat store represented 7% of the total body fat content in July and 18% of the total body fat content in August. Visceral fat content was more constant between June and March in females and greater in females except in August when males contained 176% more visceral fat.

The involvement of changes in visceral fat content with changes in total body fat content was examined by subtracting visceral fat content from total body fat content. In 2+ males, the large increase in total body fat content occurring in July was due mostly to an increase in visceral fat content. Total body fat content of 2+ males did not change during August, although somatic body fat content (total body fat content minus visceral fat content)

FIGURE 17. Visceral fat content of 2+ yellow perch at time of collection. Mean ± 1 SE. Circles - 2+ males; triangles - 2+ females.


VISCERAL FAT (G)
0.0
0.1
0.2
J
J
A
S
O
N
D
J
F
M
A
1977
MONTH

increased. The increase in somatic body fat content in August occurred while visceral fat content decreased rapidly. In 2+ females, the increase in visceral fat content occurring in July was responsible for the increase in total body fat content. Excluding July for 2+ females and July and August for 2+ males, visceral fat content fluctuations did not affect fluctuations in total body fat content.

IV. Discussion

Yellow perch from Lac Ste. Anne are intermediate in terms of length and weight at the end of the second and third years of life when compared with other populations. A large number of studies on growth of yellow perch have been conducted (Harkness, 1922; Eschemeyer, 1936, 1937; Fortin and Magnin, 1972; Grimaldi and Leduc, 1973; Ney and Smith, 1975; Pycha and Smith, 1955; Langford and Martin 1940; Hile and Jobes, 1940; Jobes, 1952; El-Zarka, 1959).

Perch from Lac Ste. Anne, in the present study, showed differences in the timing of body growth when compared with other perch populations. Although these perch began increasing in body weight and body length at the same time as other populations, they continued growing in the winter and showed 60.4% of the annual increase in total body weight between September and March. Hile and Jobes (1940) found that 77% of the total production of 1936-38 of Saginaw Bay yellow perch took place between September and December; 45% of this production occurred in October. This is the only other study which documents growth of perch taking place after October and the only other study which involved sampling perch during the winter.

Growth in other populations of yellow perch takes place from June to September (Langford and Martin, 1940; Jobes, 1952; Pycha and Smith, 1955; Ney and Smith, 1975). LeCren

(1947) found that growth in European perch from Lake Windermere occurred between May and October.

Coble (1965) and LeCren (1958) have both provided evidence for the importance of temperature in regulating perch growth. Body growth in weight begins in the spring when water temperature reaches about 14° C. and seems to cease by September (Coble, 1965; El-Zarka, 1959; Fortin and Magnin, 1972; Jobes, 1952). According to Medford (1976), Lac Ste. Anne reaches a temperature of 14° C. in mid-May and cools below this temperature in mid-September. Therefore, although yellow perch from Lac Ste. Anne commence growth at temperatures similar to other perch populations, growth continues in these fish after the water temperature drops below the minimum at which perch growth generally occurs.

Lac Ste. Anne male and female perch are similar, in terms of standard body length and body weight, to the end of their second year of life only. LeCren (1958) also found little consistent difference in length and weight between young male and female European perch. He suggests that similar growth between the sexes for the first two years of life is probably typical of perch in general. It also seems typical for populations of Perca fluviatilis and Perca flavescens, including perch from Lac Ste. Anne, that females show consistently faster growth rates after the second year of life (McCormack, 1965; LeCren, 1958; Carlander, 1950; Jobes, 1952; Hile and Jobes, 1940; Grimaldi and Leduc, 1973).

Two+ perch collected in June 1977 were much shorter (12 mm, 41% male; 14 mm, 16% female) and lighter (3.9 g, 15% male; 5.1 g, 45% female) than those collected as 1+ perch in January and March. The larger 1+ perch were similar, in length and weight, to the June 1976 2+ perch suggesting that, if growth had ceased, the 2+ perch of June 1976 and 1977 would be similar in size. The smaller 2+ perch obtained in June 1977 were similar in size to perch captured as 1+ in October 1976. The difference in size of the January 1+ females and January and March 1+ males, when compared with the June 1977 2+ perch, may be due to sampling gear selectivity, the presence of more than one population in the lake, or to movements of fish.

The increase in length and weight of 1+ perch between October and January may have been a result of growth in response to an increased level of primary production. The winter of 1976-1977 was atypical due to very little snow fall which allowed a high level of light penetration and consequently resulted in a high level of primary productivity. Nakashima and Leggett (1975) state that, in general, fish frequently respond to increased levels of production at lower trophic levels by increased growth rates. The absence, in June, of the larger 1+ perch may have been a result of a size-dependent mortality over spawning or a size-selective predation of these fish.

Few workers (Shul'man, 1974; Brett et al., 1969) have studied the changes in body composition which take place

with body growth. Growth in body weight for yellow perch at Lac Ste. Anne occurred mostly as a result of increases in body water content and increases in total body protein content although these increases occurred concurrently in 2+ males only. Changes in total body weight were correlated with changes in total body protein content in 1+ males and with changes in total body protein, total body fat and total body water contents in 1+ females. Increments in total body weight were correlated with increments in total body water content only in 1+ female and 2+ perch. (Fat content of the body was small enough in all cases that changes in it did not affect body weight.) For 1+ males, grams of body water increased most rapidly in June and between October and January while the greatest increases in grams of protein took place in June and August. In 1+ females, grams of water and protein increased most between October and January; in this period the increase in grams of water was 5X greater than that of protein. In 2+ males, the increases in both total body protein and total body water occurred at the same time. For 2+ females, increases in grams of body water and protein were larger in August and September but the largest increase in total body protein content took place in August.

For all sex and age groups, total body protein, total body fat, and total body water, when summed, accounted for 96.8% of the total body weight increases during the periods of body composition analysis (June 1976–June 1977). Craig

(1977) reported that, on a wet weight basis, European perch contained 6.2% ash and 0.13% carbohydrate and that the ratio of non-protein nitrogen to total nitrogen was 0.158. In this study of Lac Ste. Anne perch, nitrogen values were not corrected for non-protein nitrogen. Therefore the calculated protein values may be an over-estimate. This would result in an over-estimation of total body protein contents.

When total body and gonad fat as well as total body and gonad protein contents were multiplied by their calorific equivalents (Kleiber, 1975) and then summed, they accounted for 109% of the total body energy contents (kcal/fish including gonad) of yellow perch from Lac Ste. Anne between June 1976 and June 1977. Craig (1977) found significant differences between values for body energy content (kcal/g wet weight) obtained by calorimetry and conversion with fat and protein with the latter being 7.2% greater. The over-estimation of body and gonad protein content and of energy content by conversion of fat and protein may account for the calculated total body energy content of perch from Lac Ste. Anne being over 100%.

Condition has been used to examine gonad cycles and alternating periods of growth in length and weight (LeCren, 1951). Condition of 1+ male perch at Lac Ste. Anne changed little between July 1976 and January 1977 while condition in 1+ females changed little between July and October suggesting that increases in body length and body weight

occurred at the same rate over these periods. The increases in condition in March for 1+ males and January for 1+ females occurred when large increases in total body and gonad wet weight took place. The changes in condition indicate that body growth of 1+ perch was isometric in the summer and allometric in the winter. Although condition in 2+ males and females changed similarly through the year, females tended to be in better condition than males. Condition reached a peak value in August for males and in September for females, just prior to the initial increases in gonad weight. Body growth of 2+ perch may have been allometric in summer since condition increased over the summer.

A similar situation, condition increasing until gonad development begins, also existed in perch from Lake Erie (Jobes, 1952) and in European perch from Lake Windermere (LeCren, 1951). LeCren (1951), Khashem (1970) and MacKinnon (1972) all suggested that the body was involved with gonad construction since condition declined while gonad weight increased. Condition declined, in 1+ male and 2+ perch from Lac Ste. Anne, while gonad weight increased but condition in these fish then increased in March prior to spawning in May. Lake Windermere perch showed an increase in condition just prior to spawning which was due to increases in gonad and body wet weights (LeCren, 1951). The drop in body weight and condition of perch from Lac Ste. Anne which took place after spawning also occurred in European perch (LeCren

,1951) and northern pike (Medford, 1976).

It has been generally assumed that a greater condition value indicates a larger energy content of an individual fish. This does not occur in perch from Lac Ste. Anne. There was no correlation between condition and standardized values (100X component/mean standard length^3) of total body fat, and total body protein contents as well as total somatic energy content for any age sex group. Therefore condition may not represent a relationship between changes in body weight with body composition and condition may not be a good indicator of the energy content of a fish. This is contrary to the general assumption and to the results of MacKinnon (1972) which both suggest that the "plumper" the fish (the greater the condition) the more energy the fish contains and the better suited the fish is to its habitat. MacKinnon (1972) found in American plaice that, in general, changes in total body energy storage were correlated with changes in condition.

According to Markevich and Shatunovskiy (1969), fluctuations in quantity and quality of fats are due to the fact that fats are the basic energy-producing material, ensuring the basal and active metabolism of fish, and development of the gonads and protein synthesis. Body fat seemed to be utilized as an energy source for gonad construction in 1+ male and 2+ male perch from Lac Ste. Anne while 2+ females used body fat and body protein for ovary construction. Newsome and Leduc (1975) found that, in

Laurentian populations of yellow perch, body fat content decreased in both sexes from the time at which gonads begin developing until after spawning. The decline in body fat content was much more pronounced in these fish than in perch from Lac Ste. Anne and perch from these Laurentian lakes had lower body fat content than perch from Lac Ste. Anne.

Although the liver is closely involved with gonad development in many fishes, including European perch (Makarova, 1973), liver analysis of perch from Lac Ste. Anne was not conducted due to the small size of the liver and the presence of a large number of parasite cysts in the liver. Makarova (1973) found that, in European perch, liver stores of fat and protein and visceral fat deposits were utilized for gonad construction. He found that fat deposition began in June with the formation of visceral fat deposits. Liver and visceral fat depots decreased between July and October as the gonads developed to maturity stages III-IV. Kulayev (1927) (cited by Makarova, 1973) found that the greatest activity of spermatogenesis in Perca fluviatilis was made possible by depot lipids whereas the main increases in ovary weight take place with a minimum expenditure of lipids and utilized protein metabolism and exogenous lipid. Makarova (1973) suggested that the accumulation of protein in the female perch gonad between October and March was made at the expense of liver protein. Makarova (1973), Love (1970), and MacKinnon (1972) suggest that, in non-fatty fish, protein is depleted after body lipid stores have been used up.

In 2+ perch from Lac Ste. Anne, visceral fat stores were intimately involved with germinal tissue construction. The behavior of visceral fat deposits of perch from Lac Ste. Anne is similar to that described by Makarova (1973) for European perch. In both populations, visceral fat depots were rapidly built up in the early summer and used up in the early fall. Males had twice the visceral fat of females in August and the overall rise and fall in visceral fat was more dramatic in males. Krivobok and Shatunovskiy (1971) suggest that the more intenstive accumulation and reduction of visceral fat, which is observed in male perch, is associated with greater activity of lipid metabolism, especially phospholipid metabolism, in the course of spermatogenesis.

In Lac Ste. Anne 2+ males, visceral fat is used for testes development in August whereas body fat is utilized for testes construction from September through January. Visceral fat and body fat were more equally involved in construction of the 2+ perch ovary. Changes in visceral and body fat contents were less dramatic and more protracted in 2+ females. The utilization of visceral fat reserves, for initial gonad construction, followed by depletion of other fat reserves, until the end of spawning, also occurs in Atlantic herring (Gakichko and Dubrovskaya, 1970), lake whitefish (Reshetnikov, 1970), and Arctic char (Matsuk and Lapin, 1972).

Based on the data of Korde (1968), Makarova (1973)

suggests that alterations of fat content of the muscles of the perch duplicates the alterations of fat content of the viscera. Therefore it seems that all of the body fat in perch may be used as an energy store. Makarova (1973) and Newsome and Leduc (1975) suggest that perch use body fat for gonad development and as an energy source for overwintering since immature perch also showed declines in body fat content during the winter.

The differences in timing of deposition of fat and protein into the gonads of 1+ and 2+ males as well as 2+ female perch are probably a result of the demands that gonad construction makes of the body reserves. In 2+ perch, protein and fat are incorporated into the gonad most rapidly before January. The 1+ male gonad increases in protein and fat most rapidly between January and March. If the demands made of the body by gonad development and overwintering occurred concurrently then it is possible that such a great energy drain might limit the number of 2+ or older perch which would survive to spawn. Newsome and Leduc (1975) found that the energy drain of the body of yellow perch females for gonad development resulted in a sex-selective mortality. In March the 2+ female gonad of perch from Lac Ste. Anne contained 4425 calories which was 14% of the total body energy content. Although the 1+ male testes represents a greater percentage of the total body energy content in March than of 2+ males (10% and 9% respectively), the gonad of the 2+ male contains 2081 calories while the 1+ male

gonad contains 911 calories.

In conclusion, the timing of body growth of perch from Lac Ste. Anne is different for 1+ and 2+ males and females. The sexual dimorphism in body length and body weight which is prevalent in other populations of perch also occurs in perch from Lac Ste. Anne. Increases in body weight continued until at least January for 1+ females and until January for 1+ males and 2+ males and until March for 2+ females. Body length increased until March in 1+ males, until at least January in 1+ females and until March in 2+ perch. Body growth, during the summer, was isometric for 1+ perch and allometric for 2+ perch. Weight increased more rapidly than length in the summer for 2+ perch. Body growth occurred as a result of protein and mostly water accumulation for all sex and age groups and, except in 2+ males, the larger increases in body protein and body water contents do not occur concurrently. Changes in energy, protein, or fat contents did not necessarily occur with concomitant changes in length and/or weight and the changes in total somatic energy content are not correlated with changes in condition. Condition, then, may not be a good indicator of the energy content of a fish.

Gonad construction takes place at different times for the different age and sex groups but all utilize body fat as the energy source for gonad construction. Females also use body protein for synthesis of reproductive tissue. Germinal tissue production is more demanding of the 2+ fish and

especially the 2+ females due to the size of the gonad produced, the degree of body constituent depletion during gonad construction, and the amount and quality of materials composing the mature gonad.

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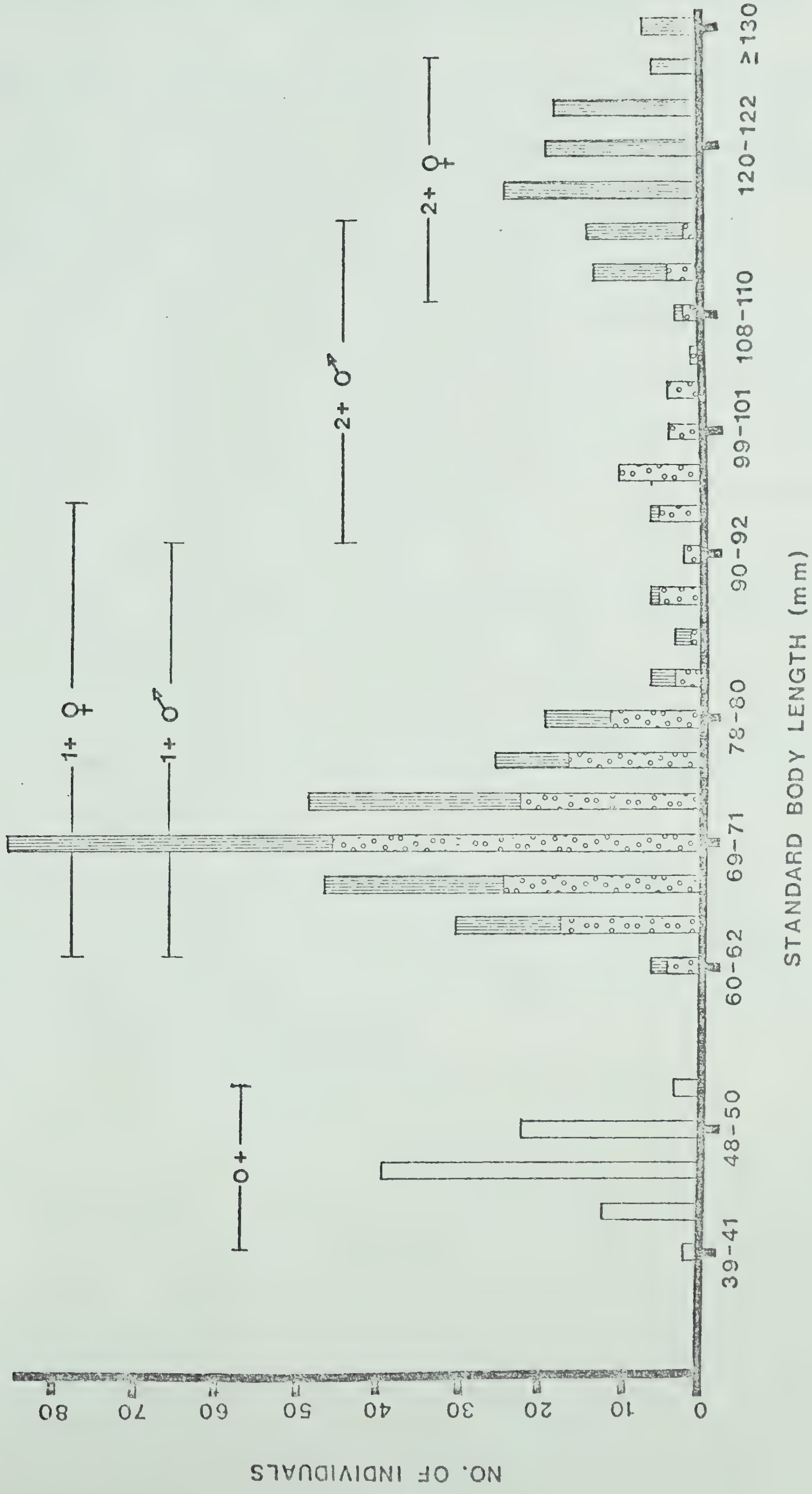
APPENDIX

Appendix A. Age Determination by Standard Length

Perch from Lac Ste. Anne were distinctly segregated on the basis of standard body length during, at least, the first three years of life (Appendix Fig. 1). This allowed ageing from standard body length measurement. When individuals intermediate in size were present, the left opercular was removed and the exact age was determined.

APPENDIX FIGURE 1. Length - frequency histogram of October 1976 Lac Ste. Anne yellow perch.

Open - immature; circles - mature males;
Lines - mature females.


NO. OF INDIVIDUALS
0
10
20
30
40
50
60
70
80
STANDARD BODY LENGTH (mm)
39-41
48-50
60-62
69-71
78-80
90-92
99-101
108-110
120-122
≥130
0+
1+ ♀
1+ ♂
2+ ♂
2+ ♀

Appendix B. Body Protein Content Determination

Vials were uncapped and allowed to stand in a drying oven at 70° C for one hour prior to removal of approximately 100 mg of body power for nitrogen determination. Hydrochloric acid (0.1 N) was prepared from Dilut-It analytical concentrate vials (J. T. Baker Chemical Company, Phillipsburg, N.J.). The acid was standardized by titration with 0.1N NaOH using phenophthalein as the indicator. The sodium hydroxide was previously standardized by titrating with 0.100 N potassium biphthalate using phenophthalein as the indicator. THAM (Tris-(hydroxymethyl)-aminomethane, Fisher certified primary standard) was used to monitor accuracy and precision of nitrogen determination. Blanks were also run with each series of samples to correct for nitrogen contamination.

Protein content was calculated as a percent of the dry body weight. THAM contained 11.06±0.41% (mean ± 1 SD) nitrogen. This value was 5.06% lower than the known nitrogen content (11.65%) of the standard.

Appendix C. Body Lipid and Visceral Fat Content Determination

Prior to the extraction, vials of body powder or entire viscera were held in a drying oven for 1 hour at 70° C and then placed in a desiccator overnight before weighing of the sample. For each 15 samples, duplicate blanks were run to correct for error due to non-volatile contaminants of the chloroform/methanol mixture. Single samples of a homogenate of perch body powder were also run, as a standard, with each group of samples of body powder or viscera. Fat content was calculated as a percent of the dry body weight. Visceral fat content was expressed as a percent of the viscera dry weight. The perch body powder standard used in all sessions of body lipid content determinations contained 7.26±0.28% (mean ± 1 SD) lipid. The pike gonad powder, used as a standard in all sessions of visceral fat content determinations, contained 15.72±0.69% (mean ± 1 SD) fat.

Appendix D. Gonad Lipid Content Determination

Vials containing gonad powder were held in a drying oven at approximately 70° C for 1 hour and then placed in a desiccator overnight. Five milligrams of gonad powder was placed in each test tube after which 20 ul of absolute ethanol was added. Lipid analysis was then carried out according to Frings et al. (1972). The absolute ethanol was prepared by refluxing 95% ethanol over $Mg(OH)_2$ for 24 hours. Refluxing removed all water from the ethanol. The change in the slope of the standard curve suggested that the ethanol began taking up water. Consequently, the standard curve for each run was corrected, by adjusting values of standards of following runs to those of the initial run, before the fat content of the gonad samples was calculated.

Lipid content of each gonad was determined in duplicate. A standard homogenate of pike ovary was analyzed during each run to determine the variability of the technique. Prior to determining the fat content of the pike ovary homogenate using Frings' method, the lipid content of the pike ovary was determined gravimetrically after Soxhlet extraction. Using the Soxhlet extraction procedure, the pike ovary contained 16.65±0.41% lipid. The pike ovary contained 16.21±1.59% (mean ± 1 SD) lipid according to Frings' method. The mean difference in fat content of the pike ovary, as determined by both techniques, was 2.64%. The difference between the means was not significantly different (t=1.10)

at $p=0.01$ ($df=14$). Gonad lipid content was calculated as a percentage of the dry gonad weight.

Appendix E. Gonad Protein Content Determination

Vials containing gonad powder were placed in a drying oven at 70° C for about one hour and then held in a desiccator overnight. Pre-standardized hydrochloric acid (Certified Hydrochloric acid Solution N/100, Fisher Scientific Co.) was used to titrate the distillate. The percent nitrogen value obtained was multiplied by 6.25, to give the percent crude gonad protein (Kleiber, 1975). Protein content of each gonad was determined in duplicate.

Gonad protein was calculated as a percentage of the dry gonad weight. THAM was used as a standard and over all runs contained 10.82±1.12% (mean ± 1 SD) nitrogen. This was 7.12% less than the known nitrogen content of THAM.

Appendix Table 1. Dates of sampling and methods of collection of Lac Ste. Anne yellow perch.

FISHING DATES	GEAR USED
March 15-19, 1976	GN.
May 7-13 , 1976	GN.
June 2-3, 1976	GN.
July 6-7, 1976	GN.
August 3-4, 1976	GN, TR, S.
September 7-8, 1976	GN, TR.
October 14-15, 1976	TR.
January 22-23, 1977	GN.
March 2-3, 1977	GN.
May 31 - June 2, 1977	GN, TR, S.
July 2-3, 1977	GN, TR, S.

GN - gillnet

TR - trawl

S - seine

Appendix Table 2. Standard body length (mm) of Lac Ste. Anne yellow perch at time of collection. Mean ± 1 SE.

	1976 Mar 15-19	May 7-13	Jun 2-3	Jul 6-7	Aug 3-4	Sep 7-8	Oct 14-15	1977 Jan 22-23	Mar 2-3	May 31-Jun 2	Jul 2-3
1+ male	XXX	XXX	49.50 ±0.62	62.47 ±0.23	64.32 ±0.35	70.13 ±0.74	70.71 ±0.41	85.87 ±1.77	93.76 ±1.62	70.21 ±0.62	77.64 ±1.07
n			20	165	139	91	144	16	25	62	13
1+ female	XXX	XXX	50.40 ±0.47	63.02 ±0.30	65.03 ±0.42	68.38 ±0.57	71.01 ±0.42	92.78 ±3.09	XXX	71.26 ±0.75	79.49 ±1.00
n			35	79	96	73	124	18		62	20
2+ male	82.72 ±1.03	81.50 ±0.54	82.62 ±0.01	84.53 ±0.47	92.05 ±1.15	96.70 ±0.90	99.50 ±1.24	112.35 ±2.35	109.43 ±1.61	103.20 ±2.22	107.00 ±1.18
n	18	115	72	122	81	50	38	31	44	5	45
2+ female	XXX	82.01 ±0.85	85.17 ±0.44	88.69 ±0.52	96.51 ±0.60	101.20 ±3.49	119.23 ±0.46	121.93 ±0.42	121.70 ±0.42	120.40 ±2.30	119.53 ±2.50
n		71	122	98	109	30	88	307	453	31	37

X - Not Collected

Appendix Table 3. Total body weight (g) at time of collection. Mean ± 1 SE.

	1976 Mar 15-19	May 7-13	Jun 2-3	Jul 6-7	Aug 3-4	Sep 7-8	Oct 14-15	1977 Jan 22-23	Mar 2-3	May 31-Jun 2	Jul 2-3
1+ male	XXX	XXX	1.614 ±0.008	4.083 ±0.050	4.206 ±0.080	5.557 ±0.250	5.927 ±0.120	$10.615^{@}$	10.862 ±1.181	5.672 ±0.200	8.857 ±0.410
n			8	140	114	68	122	16	8	50	13
1+ female	XXX	XXX	1.687 ±0.300	4.057 ±0.860	4.495 ±0.100	5.084 ±0.200	5.665 ±0.120	$15.378^{@}$	XXX	6.174 ±0.260	10.070 ±0.520
n			23	54	71	49	100	18		51	20
2+ male	8.160 ±0.30	8.683 ±0.34	9.615 ±0.250	10.656 ±0.230	14.944 ±0.390	16.169 ±0.620	17.252 ±0.830	$23.891^{@}$	22.261 ±1.808	16.663 ±1.310	23.760 ±0.820
n	18	51	45	97	58	25	14	31	17	5	45
2+ female	XXX	9.824 ±0.380	11.260 ±0.200	12.482 ±0.300	16.679 ±0.370	20.484 ±0.890	32.082 ±0.490	33.956 ±0.427	34.985 ±0.435	27.583 ±2.600	33.800 ±2.170
n		55	58	72	84	6	65	274	430	13	37

X - Not Collected

@ - Total body weight = body - minus - gonad weight + gonad weight.

Appendix Table 4. Total body protein content (g) at time of collection. Mean ± 1 SE.

	1976							1977		
	Mar 15-19	May 7-13	Jun 2-3	Jul 6-7	Aug 3-4	Sep 7-8	Oct 14-15	Jan 22-23	Mar 2-3	May 31-Jun 2
1+ male	XXX	XXX	0.28±0.03	0.75±0.10	0.83±0.08	1.08±0.22	0.98±0.08	1.10±0.08	1.24±0.15	0.85±0.06
n			5	4	6	4	3	4	5	5
1+ female	XXX	XXX	0.34±0.03	0.62±0.01	0.72±0.05	0.69±0.04	0.95±0.07	2.94±0.34	XXX	1.16±0.06
n			5	7	5	5	10	4		5
2+ male	1.16±0.06	1.55±0.02	1.44±0.09	1.85±0.14	2.50±0.10	2.97±0.38	3.08±0.54	3.61±0.52	4.80±0.55	2.83±0.32
n	13	8	5	5	10	5	5	4	5	5
2+ female	XXX	1.58±0.22	1.56±0.07	2.23±0.15	2.65±0.33	4.22±0.26	4.92±0.17	3.98±0.24	5.08±0.55	5.71±0.55
n		5	5	5	5	5	9	6	5	5

X - Not Collected

Appendix Table 5. Body water content (g H_2O/100 g wet body weight) at time of collection. Mean ± 1 SE.

	1976							1977		
	Mar 15-19	May 7-13	Jun 2-3	Jul 6-7	Aug 3-4	Sep 7-8	Oct 14-15	Jan 22-23	Mar 2-3	May 31-Jun 2
1+ male	XXX	XXX	76.79 ±0.38	76.72 ±0.16	76.66 ±0.25	76.86 ±0.20	78.05 ±0.80	78.97 ±0.33	78.75 ±0.10	79.04 ±0.40
n			5	18	19	14	16	8	12	9
1+ female	XXX	XXX	76.42 ±0.30	77.08 ±0.11	76.82 ±0.23	76.61 ±0.18	77.74 ±0.10	78.48 ±0.75	XXX	77.42 ±0.15
n			5	17	17	17	16	4		8
2+ male	81.19 ±0.40	80.08 ±0.44	76.61 ±0.25	75.62 ±0.14	73.82 ±0.27	75.43 ±0.24	76.71 ±0.15	78.25 ±0.22	77.56 ±0.22	76.26 ±1.02
n	13	24	12	11	10	11	12	9	11	5
2+ female	XXX	78.85 ±0.26	76.30 ±0.30	75.79 ±0.21	75.26 ±1.70	75.31 ±0.11	77.16 ±0.22	78.97 ±0.88	77.67 ±0.23	75.52 ±0.42
n		13	10	10	10	10	11	9	10	10

X - Not Collected

Appendix Table 6. Total body water content (g/fish excluding gonad) at time of collection. Mean ± 1 SE.

	1976							1977		
	Mar 15-19	May 7-3	Jun 2-3	Jul 6-7	Aug 3-4	Sep 7-8	Oct 14-15	Jan 22-23	Mar 2-3	May 31-Jun 2
1+ male	XXX	XXX	1.30±0.16	3.02±0.14	3.58±0.12	4.80±0.53	4.44±0.21	7.14±0.75	6.39±0.33	4.45±0.24
n			5	18	19	14	16	8	12	9
1+ female	XXX	XXX	1.53±0.12	2.90±0.06	3.31±0.11	3.53±0.15	4.49±0.22	14.51±1.56	XXX	5.13±0.23
n			5	17	17	17	16	4		8
2+ male	7.09±0.32	8.12±0.45	6.76±0.25	8.00±0.45	10.72±0.33	12.54±0.88	13.40±1.07	15.58±1.97	17.34±1.64	12.49±0.85
n	13	24	13	11	10	11	12	9	11	5
2+ female	XXX	7.89±0.50	7.05±0.18	9.67±0.51	11.87±0.66	17.50±0.89	22.74±0.62	20.20±0.93	24.11±1.53	26.16±3.03
n		13	13	10	10	10	11	9	10	10

X - Not Collected

MA_2 - March 1977

JE_2 - June 1977

Appendix Table 7. Total body lipid content (g) at time of collection. Mean ± 1 SE.

	1976							1977		
	Mar 15-19	May 7-13	Jun 2-3	Jul 6-7	Aug 3-4	Sep 7-8	Oct 14-15	Jan 22-23	Mar 2-3	May 31-Jun 2
1+ male	XXX	XXX	&&&	0.09±0.01	0.12±0.01	0.17±0.03	0.11±0.01	0.13±0.02	0.16±0.01	0.14±0.01
n				10	8	9	9	5	9	7
1+ female	XXX	XXX	&&&	0.09±0.003	0.11±0.01	0.11±0.01	0.13±0.01	0.25±0.02	XXX	0.18±0.01
n				9	10	9	9	4		8
2+ male	0.13±0.02	0.14±0.001	0.24±0.01	0.33±0.01	0.48±0.03	0.45±0.05	0.32±0.03	0.29±0.03	0.39±0.07	0.39±0.09
n	9	19	13	10	4	9	11	9	10	5
2+ female	XXX	0.20±0.02	0.26±0.01	0.38±0.02	0.41±0.04	0.55±0.03	0.58±0.04	0.40±0.05	0.45±0.04	0.92±0.16
n		12	13	10	9	10	10	7	9	10

X - Not Collected

& - Not Determined

Appendix Table 8. Total somatic energy content (cal.) at time of collection. Mean ± 1 SE.

	1976							1977		
	Mar 15-19	May 7-13	Jun 2-3	Jul 6-7	Aug 3-4	Sep 7-8	Oct 14-15	Jan 22-23	Mar 2-3	May 31-Jun 2
1+ male	XXX	XXX	&&&	5282 ±348	6209 ±439	5501 ±758	5903 ±350	9518 ±1050	7740 ±470	5599 ±493
n				8	9	5	7	5	5	5
1+ female	XXX	XXX	&&&	4709 ±163	5760 ±228	4913 ±325	5362 ±159	16998 ±1903	XXX	7458 ±290
n				8	6	8	5	4		5
2+ male	8312 ±527	9646 ±671	9372 ±354	12608 ±748	19157 ±029	18707 ±2234	17514 ±1829	18439 ±2031	23131 ±3271	18653 ±2306
n	7	16	6	10	10	5	5	7	7	5
2+ female	XXX	10741 ±630	10448 ±542	14701 ±766	22575 ±2256	26489 ±1623	29382 ±2127	23629 ±1392	28412 ±3319	38029 ±3235
n		8	6	10	5	5	5	5	5	5

X - Not Collected

& - Not Determined

Appendix Table 9. Gonad Weight (g) at time of collection. Mean ± 1 SE.

	1976							1977		
	Mar 15-19	May 7-13	Jun 2-3	Jul 6-7	Aug 3-4	Sep 7-8	Oct 14-15	Jan 22-23	Mar 2-3	May 31-Jun 2
1+ male	XXX	XXX	0.001 ±0.001	0.002 ±0.001	0.010 ±0.004	0.197 ±0.029	0.198 ±0.013	0.521 ±0.049	0.457 ±0.037	0.022 ±0.008
n			12	25	25	25	25	17	15	9
1+ female	XXX	XXX	0.004 ±0.001	0.016 ±0.001	0.017 ±0.001	0.006 ±0.001	0.035 ±0.001	1.899 ±0.145	XXX	0.034 ±0.004
n			12	25	25	26	25	6		8
2+ male	0.414 ±0.03	0.206 ±0.03	0.055 ±0.005	0.011 ±0.001	0.045 ±0.004	0.707 ±0.056	0.809 ±0.044	1.092 ±0.069	1.237 ±0.075	0.039 ±0.010
n	13	23	22	17	25	27	25	27	28	5
2+ female	XXX	0.052 ±0.004	0.058 ±0.004	0.054 ±0.003	0.113 ±0.009	0.312 ±0.042	1.260 ±0.054	2.525 ±0.085	4.066 ±0.204	0.399 ±0.053
n		13	23	24	25	26	26	26	25	10

X - Not Collected

Appendix Table 10. Body protein content (g protein/100 g wet body weight) at time of collection. Mean ± 1 SE.

	1976							1977			
	Mar 15-19	May 7-13	Jun 2-3	Jul 6-7	Aug 3-4	Sep 7-8	Oct 14-15	Jan 22-23	Mar 2-3	May 31-Jun 2	Range Test
1+ male	XXX	XXX	16.76 ±0.28	16.48 ±0.29	16.43 ±0.55	16.83 ±0.07	15.66 ±0.21	15.07 ±0.45	15.40 ±0.36	14.79 ±0.20	JE_2 JA MA_2 OC AU JU JE SE
n			5	4	6	4	5	4	5	5	
1+ female	XXX	XXX	17.04 ±0.18	16.57 ±0.27	16.85 ±0.08	16.29 ±0.15	15.54 ±0.33	15.90 ±0.50	XXX	16.17 ±0.56	OC JA JE_2 SE JU AU JE
n			5	7	5	5	10	4		5	
2+ male	13.31 ±0.34	14.56 ±0.18	16.61 ±0.27	17.28 ±0.28	17.18 ±0.24	17.58 ±0.13	17.06 ±0.28	16.07 ±0.31	17.51 ±0.20	16.80 ±0.72	JA JE JE_2 OC AU JE MA_2 SE
n	13	8	5	5	10	5	5	4	5	5	
2+ female	XXX	15.34 ±0.21	16.67 ±0.21	16.39 ±0.18	16.87 ±0.55	17.57 ±0.06	16.72 ±0.15	15.06 ±0.92	17.36 ±0.28	15.90 ±0.23	JA JE_2 JE OC AU JU MA_2 SE
n		5	5	5	5	5	9	6	5	5	

X - Not Collected

MA_2 - March 1977

JE_2 - June 1977

Appendix Table 11. Body lipid content (g lipid/100 g wet body weight) at time of collection. Mean ± 1 SE.

	1976 Mar 15-19	May 7-13	Jun 2-3	Jul 6-7	Aug 3-4	Sep 7-8	Oct 14-15	1977 Jan 22-23	Mar 2-3	May 31-Jun 2	Range Test
1+ male	XXX	XXX	&&&	2.59 ±0.10	2.62 ±0.12	2.31 ±0.11	2.02 ±0.13	1.70 ±0.20	1.94 ±0.14	2.28 ±0.16	JA MA_2 OC JE_2 SE JU AU
n				10	8	9	9	5	9	7	
1+ female	XXX	XXX	&&&	2.59 ±0.06	2.60 ±0.11	2.22 ±0.13	2.21 ±0.17	1.41 ±0.15	XXX	2.70 ±0.08	JA OC SE JU AU JE_2
n				9	10	9	9	4		8	
2+ male	1.45 ±0.10	1.39 ±0.08	2.75 ±0.11	3.07 ±0.10	3.36 ±0.06	2.57 ±0.15	1.93 ±0.15	1.51 ±0.12	1.59 ±0.16	2.26 ±0.41	JA AU OC JE_2 SE JE JU AU
n	9	19	13	10	4	9	11	9	10	5	
2+ female	XXX	1.93 ±0.11	2.81 ±0.13	2.95 ±0.11	2.62 ±0.18	2.39 ±0.12	1.97 ±0.10	1.63 ±0.18	1.48 ±0.09	2.63 ±0.21	MA_2 JA OC SE AU JE_2 JE JU
n		12	13	10	9	10	10	7	9	10	

X - Not Collected

& - Not Determined

MA_2 - March 1977

JE_2 - June 1977

Appendix Table 12. Visceral fat content (g) of 2+ Lac Ste. Anne perch at time of collection. Mean ± 1 SE.

	1976 Jun 2-3	Jul 6-7	Aug 3-4	Sep 7-8	1977 Mar 2-3
2+ male	0.031	0.016	0.134	0.041	0.039
	±0.007	±0.002	±0.067	±0.005	±0.006
n	5	3	5	5	5
2+ female	0.039	0.028	0.076	0.069	0.052
	±0.004	±0.005	±0.025	±0.012	±0.005
n	5	5	5	5	5

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